REMOVAL SITE EVALUATION REPORT

Babbitt Ranches, LLC – Milestone Hawaii Stewardship Project (Section 9 Lease Abandoned Uranium Mine)

CERCLA Docket No. 2016-13

Prepared for:

U.S. Environmental Protection Agency
Region IX

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Site Name/Project: Babbitt Ranches, LLC – Milestone Hawaii Stewardship Project, Section 9 Lease Abandoned Uranium Mine

Site Location: Section 9, Township 27 North, Range 10 East of the Gila and Salt River Base and Meridian near Cameron, Coconino County, Arizona

Approval Entity: EPA Region IX

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ACRONYMS

95UCL	95% Upper Confidence Limit
ACF	Area Correction Factor
ADD	Average Daily Dose
ADEQ	Arizona Department of Environmental Quality
AOC	Administrative Settlement Agreement and Order on Consent
ANOVA	Analysis of Variance
APE	Area of Potential Effect
AUF	Area Use Factor
AUM	Abandoned Uranium Mine
BCG	Biota Concentration Guide
BLM	U.S. Bureau of Land Management
BOR	U.S. Bureau of Reclamation
BRA	Background Reference Area
BSA	Background Study Area
BTF	Biota Transfer Factor
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
cpm	Counts per Minute
cps	Counts per Second
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
CY	Cubic Yards
DCF	Dose Conversion Factor
DMP	Data Management Plan
DOE	Department of Energy
DQO	Data Quality Objective
DSC	Dwass, Steel, Critchlow test
EC_{10}	Concentration that causes an effect in 10% of organisms
EC_{20}	Concentration that causes an effect in 20% of organisms
EcoCSM	Ecological Conceptual Site Model
EcoSRE	Ecological Streamlined Risk Evaluation
EcoSSL	Ecological Soil Screening Level
EECA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
EPC	Exposure Point Concentration
ERB	Equipment Rinsate Blank
ESL	Ecological Screening Level
FSP	Field Sampling Plan
GIS	Geographic Information System
HASP	Health and Safety Plan
HHSRE	Human Health Streamlined Risk Evaluation
HI	Hazard Index

HQ	Hazard Quotient
HQ_{LOAEL}	Hazard Quotient based on the TRV_{LOAEL}
HQ_{NOAEL}	Hazard Quotient based on the TRV_{NOAEL}
IL	Investigation Level (IL for Ra-226 is 1.24 above background)
ILCR	Incremental Lifetime Cancer Risk
LADD	Lifetime Average Daily Dose
LCR	Little Colorado River
LiDAR	Light Detection and Ranging
LOAEL	Lowest Observed Adverse Effect Level
MARSSIM	Multi-Agency Survey and Site Investigation Manual
MDC_{Scan}	Scanning Minimum Detectable Concentration
MDL	Minimum Detectable Limit
mg/kg	Milligrams per Kilogram
MQO	Measurement Quality Objective
n	Number of Samples
NAMLRP	Navajo Abandoned Mine Land Reclamation Program
NNEPA	Navajo Nation Environmental Protection Agency
NOAEL	No Observed Adverse Effect Level
NORM	Naturally Occurring Radioactive Material
OLS	Ordinary Least Squared
OSWER	Office of Solid Waste and Emergency Response (Now OLEM: Office of Land and Emergency Management)
PA	Preliminary Assessment
pCi/g	PicoCuries per Gram
PCOC	Potential Contaminants of Concern (defined in the 2016 AOC as Ra-226, uranium, arsenic, molybdenum, mercury, selenium and vanadium)
HPIC	High-Pressurized Ion Chamber
PNEC	Probable No Effect Concentration
ppm_{dw}	Parts per Million, dry weight
PRG	Preliminary Remediation Goal
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan
QMP	Quality Management Plan
r^2	Coefficient of Determination
Ra-226	Radium 226, a specific isotope of the element radium
rbAL	Risk Based Action Level
RfD	Reference Dose
RME	Reasonable Maximum Exposure
RSE	Removal Site Evaluation
SF	Slope Factor
SI	Site Inspection
ssESL	Site-specific Ecological Screening Level
SQuiRT	NOAA Screening Quick Reference Tables
SUF	Seasonal Use Factor

TENORM	Technologically Enhanced Naturally Occurring Radioactive Material
TF	Transfer Factor
tpd	Tons per Day
TRV	Toxicity Reference Value
TRV_{LOAEL}	Toxicity Reference Value based on the LOAEL value
TRV_{NOAEL}	Toxicity Reference Value based on the NOAEL value
UCL	Upper Confidence Limit
USACE	United States Army Corps of Engineers
UTL	Upper Tolerance Limit

EXECUTIVE SUMMARY

This Removal Site Evaluation (RSE) Report documents the methods, results, and evaluation of the tasks outlined in response to Administrative Settlement Agreement and Order on Consent (AOC) (EPA, 2016a). The AOC (EPA, 2016a) included these three phases of work:

- Phase I: Cultural Resources Surveys, Biological Survey and Signage.
- Phase II: Background Determination, Gamma Survey, and Soil Correlation.
- Phase III: Removal Site Evaluation, Vertical Profiling, Risk Evaluation, and Removal Volume Calculations.

This RSE Report consolidates and summarizes the results of the respective work plans, summary reports, and analysis.

The project area is located in the Little Colorado River (LCR) Valley in Coconino County, Arizona (Figure 1-1). The Site falls within the boundary of the CO Bar Ranch, which is owned and operated by the Respondent, headquartered in Flagstaff, Arizona. Section 9 is owned by the Respondent. A portion of Section 10 on CO Bar Ranch (i.e., the portion west of the LCR) is owned by the Bureau of Land Management (BLM) and leased by the Respondent. The Navajo Nation surrounds this general area and is located approximately 10 miles to the west of Section 9, one mile to the north of Section 9, and is on the adjacent Section 10 on the east side of the LCR. The Navajo Nation owns the eastern majority of Section 10 with the LCR floodplain as the dividing feature between ownership in Section 10. The land to the south is a mix of federal, state, and private owners. The project Site is not currently used by the Respondent for any purposes involving livestock or human activity. There are no structures or facilities present within the project Site related to any Respondent operations.

Field activities in support of completion of the phases of work included site mapping, gamma radiation scanning, concrete surface activity surveying, surface soil sampling, and subsurface soil sampling.

The lateral extent of soils characterized as technologically enhanced naturally occurring radioactive material (TENORM) presented in the Phase II Summary Report (dated August 9, 2018; approved August 17, 2019 [EA, 2018a]) which exceeded the investigation level (IL) within the Area of Potential Effect (APE) along with the vertical profiling results were used to develop the volume estimate of TENORM above the IL:

- The IL for radium-226 (Ra-226) is 1.24 picoCurie per gram (pCi/g) above background (AOC, Appendix A, Section 1.3)
- The resulting IL was calculated for three landforms within the APE:
  - Little Colorado River (LCR) (2.76 pCi/g)
  - Drainage (6.07 pCi/g)
  - Alluvial (6.59 pCi/g)
- The estimated volume of TENORM material exceeding the IL within the APE is 31,550 cubic yards (CY).

Conceptual on-Site repository designs were developed for Abandoned Uranium Mine (AUM) 457 and AUM 458:

- The pit at AUM 457 has an estimated capacity of 1,560 CY.
- The pit at AUM 458 has an estimated capacity of 5,670 CY.

The potential risks to human health and geological receptors were developed from exposure to seven potential contaminants of concern (PCOCs). Potential cancer risks to humans were evaluated for arsenic and Ra-226. Potential non-cancer risks were evaluated for arsenic, mercury, molybdenum, selenium, uranium, and vanadium. Potential cancer risks to arsenic in soils were evaluated in the context of EPA's acceptable risk range of $1x10^{-6}$ to $1x10^{-4}$. Additionally, in accordance with the approved Phase III Work Plan (EA, 2019c), potential radiological cancer risks were evaluated in the context of the $1x10^{-4}$ risk. This is comparable to the 12 mrem/year acceptable dose level per OSWER Directive No. 9200.4-18 (EPA 1997a; $3x10^{-4}$). Non-cancer human health and ecological risks are evaluated in the context of a single risk value.

The results of the Human Health Streamline Risk Evaluation (HHSRE) determined:

- All potential cancer risks are below or within the Environmental Protection Agency's (EPA) acceptable risk range, except for Ra-226 in AUM 458.
- All potential non-cancer risks are below EPA's acceptable risk value.

The results of the Ecological Streamlined Risk Evaluation (EcoSRE) determined:

- All potential risks for the receptors to Ra-226 in Site soils for all evaluated areas are below EPA's acceptable risk value.
- All potential risks for receptors to non-radiological PCOCs are below the EPA acceptable risk value for the non-radiological across all receptors and evaluated areas except for molybdenum in soils in AUM 458 to plants and small mammals.
- All potential risks for larger mammals to non-radiological PCOCs are below EPA's acceptable risk value.

Risk based action level (rbAL) volume estimate:

- The calculated Ra-226 rbAL varies by the evaluated receptor and exposure scenarios. For longer-term exposures (i.e., recreator exposures of 24 years for adult or combined adult and child recreator exposures of 26 years), the rbALs range from 12 to 13 pCi/g.
- The ecological Ra-226 rbAL is 160 pCi/g, based on protection of small mammals (desert shrew) and birds (rock wren).
- The volume of TENORM estimated to exceed the IL is 31,550 CY. The calculated volume of material above the rbAL of 12 pCi/g is 10,036 CY and the calculated volume of material above the rbAL of 160 pCi/g is 942 CY.

This report has been informed by 128 interagency meetings during the past 46 months. The HHSRE analyses demonstrate that all results occur within the EPA acceptable risk range, except for Ra-226 in soils from individual AUMs. The EcoSRE analyses demonstrate all of the results occur within EPA acceptable risk range, except molybdenum. A total 942 CY of TENORM is

above the rbAL value of 160 pCi/g. The property is deed restricted. Entry upon the property is prohibited pursuant to the deed restriction recorded in Coconino County and is in violation of Arizona trespass law.

1.0 INTRODUCTION

Babbitt Ranches, LLC and C.O. Bar Inc. (Respondent) through its land use ethic, conservation practices, and scientific ventures, is committed to its role as landowner and land steward, and as such is dedicated to treating the land and its communities with utmost respect, and participating with ecological processes. Babbitt Ranches voluntarily entered into an Administrative Settlement Agreement and Order on Consent (AOC) on October 25, 2016 with the U.S. Environmental Protection Agency (EPA) to perform an interim removal action, including a removal site evaluation (RSE), related to historic uranium mining activities on land currently owned by Respondent (the "Milestone Hawaii Stewardship Project" or "Project") located in Section 9, Township 27 North, Range 10 East of the Gila and Salt River Base and Meridian, near Cameron, Coconino County, Arizona (the "Site") (Figure 1-1). The AOC (EPA, 2016a) included three phases of work:

- Phase I: Cultural Resources Surveys, Biological Survey and Signage.
- Phase II: Background Determination, Gamma Survey, and Soil Correlation.
- Phase III: Removal Site Evaluation, Vertical Profiling, Risk Evaluation, and Removal Volume Calculations.

This RSE Report consolidates and summarizes the preceding three phases of data collection and analysis.

1.1 Purpose and Objectives

The purpose of this report is to present the results of the RSE and all supporting documentation from the three phases of work listed above. The objective of this report is to fulfill the requirement for a Final RSE and Completion Report set out in Section 5.3 of the Scope of Work for Removal Site Evaluation AOC (EPA, 2016a).

1.2 Initial Evaluation

Weston Solutions, Inc. (Weston) published a Preliminary Assessment (PA) report related to the legacy uranium production activities on the Site for the EPA in 2012 (Weston, 2012). Field activities performed by Weston in 2010 in support of the PA were limited to a reconnaissance and a low density (widely spaced transects) gamma radiation survey of the Site. Specific information regarding the instrumentation used to perform the gamma radiation survey or the survey protocol is not provided in Weston (2012). The EPA indicated that the detector height used was 1 meter (3 feet) above ground surface. The PA reported in that the Hazard Ranking System factors for the Site include uranium waste rock generated during mining, surface water from the Site flows into the Little Colorado River, no active drinking water wells within four miles of the site, and no schools, daycare centers, or occupied residences on Site or within 200 feet of the Site. As presented in the Phase III Work Plan the nearest residence is about 5.1 miles from the Site. The Weston PA is provided in Appendix A.

Weston performed a follow-up Site Inspection (SI) of the Site for the EPA, publishing their results in 2014 (Weston, 2014). The SI field activities performed by Weston in support of the SI included the following:

- Additional (mobile) gamma radiation survey over a larger area than in the PA.
- Stationary (static) gamma radiation measurements.
- Soil sampling both of presumed "source" and "background" areas. Soils samples were collected of surficial material (0 to 6-inch depth) and, in some cases, soil samples were also collected from deeper horizons (6 to 12-inch depth and 12 to 18-inch depth).
- Sediment sampling in drainages, depressions within mined areas, and the riparian corridor adjacent to the Little Colorado River (LCR). Sediment samples were collected from surficial material only.
- A wetlands evaluation.

Select chemistry and activity data in soils and sediments at the Site from the SI (Weston, 2014) is illustrated on Figures 1-2, 1-3, and 1-4. Additional information on the concentrations of metals, metalloids, and radionuclides in soils and sediments is available in the SI Report (Weston, 2014).

Weston (2014) reported using a 2-inch by 2-inch sodium iodide detector to perform the gamma survey, taking measurements at one-second intervals. The "field-of-view" of the detector was estimated by Weston (2014) to be a circle one-meter (3.3 feet) in diameter and was reported to be 1 meter (3 feet) above ground surface in Appendix H of the Weston report (2014).

The SI report presented Hazard Ranking System factors of contaminated soil from historic mining that have the presence of U-238, Ra-226, arsenic, lead, mercury, and molybdenum. Weston also reports that contaminate soil appears to have migrated into the western reaches of the Little Colorado River. The Weston SI is provided in Appendix B.

Weston and EPA personnel performed additional background reconnaissance at the Site on July 21, 2016 and proposed background reference areas in their memo dated October 26, 2016 (EPA, 2016b). The EPA memo is provided in Appendix C.

1.3 Work Completed Under Current AOC

The AOC (EPA, 2016a) involved three phases of work including Phase I Cultural Resources Surveys, Biological Survey and Signage; Phase II Background Determination and Gamma Survey; and Phase III Removal Site Evaluation. Numerous documents have been prepared in support of the three phases of work. This RSE Report is supported by these additional Project documents:

- Health and Safety Plan (HASP) (EA, 2016)
- Quality Management Plan (QMP) (EA, 2017b)
- Data Management Plan (DMP) (EA, 2017c)
- Quality Assurance Project Plan (QAPP) (EA, 2017f)
- Phase I Work Plan (EA, 2017a)

- Phase II Field Sampling Plan (FSP) (EA, 2017d)
- Phase II Work Plan (EA, 2017e)
- Phase II Summary Report (EA, 2018a)
- Phase III Field Sampling Plan (EA, 2018b)
- Phase III Work Plan (EA, 2019c)
- Phase III Summary Report (EA, 2020)

The Health and Safety Plan (HASP) was prepared to address procedures for project health and safety. The plan included basic safety procedures to follow while on site, emergency room directions, field activities and equipment description, an analysis of site and project hazards and hazard mitigation plans, training requirements, medical surveillance requirements, personal protective equipment, exposure monitoring, site evacuation procedures, decontamination procedures, and job safety analyses.

The Quality Management Plan (QMP) was prepared to support the activities completed under the AOC. The objective of the quality program was to ensure an appropriate level of team technical expertise related to AUM site characterization and restoration, and to ensure sufficient and appropriate data and information to support defensible decision making for the Project. The QMP describes the quality program and related systems, which are structured to support the program objectives. The QMP also describes the policies and systems for implementing and assessing the effectiveness of the quality program. The QMP was prepared in accordance with the U.S. Environmental Protection Agency (EPA) document entitled, *EPA Requirements for Quality Management Plans*, EPA QA/R-2 (EPA, 2001), and is compliant with *ASQ/ANSI E4:2014 Quality Management Systems for Environmental Information and Technology Programs* (ASQ, 2014). The approved QMP is provided in Appendix D.

The Data Management Plan (DMP) was intended for use with all data collection work associated with the Milestone Hawaii Stewardship Project under the current AOC. The DMP provided guidance associated with data collection, processing, reporting, and storage for sampling, analysis, monitoring, and other efforts to ensure that data collected was consistent and complete within the Site activities. The DMP included data types, formats, data management processes, data quality checks, and end-use products appropriate for supporting the Milestone Hawaii Stewardship Project. The approved DMP is provided in Appendix E.

The Quality Assurance Project Plan (QAPP) established the quality assurance requirements for environmental and engineering data collection to be implemented pursuant to the AOC (EPA, 2016a). The purpose of the QAPP was to provide guidance regarding the manner in which quality assurance (QA) and quality control (QC) procedures were applied to produce data that are scientifically valid, of documented quality, and legally defensible. Specific elements required in the QAPP included: project management, measurement data acquisition, assessment and oversight, data review and verification, and usability. The approved QAPP is provided in Appendix F.

The purpose of the Phase I Work Plan was to provide a plan and approach for installation of bilingual (English and Navajo) warning signs at the Project site. The objective of the Phase I Work Plan was to install sufficient signage to inform those that might access the Site of the

potential hazards that may be present. The approved Phase I Work Plan is provided in Appendix G.

The objective of the Phase II Field Sampling Plan (FSP) was to provide guidance to field personnel by defining the number, type, and location of samples to be collected; the type of analyses to be performed on these samples; and the rationale behind the sampling design and analytical program. The Phase II FSP covered work to be performed under Phase II as defined in Appendix A of the AOC (EPA, 2016a). The approved Phase II FSP is provided in Appendix H. Specifically, the Phase II FSP covered the following Phase II tasks:

- The Background Study.
- The Transect Gamma Survey.
- Soil Sampling for Gamma Survey – Soil Concentration Correlation Study.

The Phase II Work Plan covered work to be performed under Phase II as defined in Appendix A of the AOC (EPA, 2016a). The approved Phase II Work Plan is provided in Appendix I. Phase II consisted of the following four tasks:

1. The Background (desktop) Study, which identified potential background study areas and, once these areas were approved by the EPA, established background levels in soils and sediments for gamma emissions and potential contaminants of concern (PCOCs) in areas not impacted by technologically enhanced naturally occurring radioactive material (TENORM).
2. The Transect Gamma Survey, which supported defining the lateral extent of those areas impacted by mine-related TENORM as well as the magnitude of the gamma emissions within the mine-related TENORM impacted areas.
3. Soil Sampling for Gamma Scan – Soil Concentration Correlation Study, which had the goal of establishing mathematical relationships to accurately estimate PCOC levels in soils and sediments based on their gamma radiation level.
4. Summary Report, which summarized the Phase II results and provided the raw data generated by the work.

The Phase II Summary Report documented the methods, results, and evaluation of the Phase II tasks. The approved Phase II Summary Report is provided in Appendix J. The report provided a detailed discussion of:

- The background data population statistics.
- A site-wide map of the predicted gamma radiation exposure rates.
- The correlations between the PCOCs and gamma emission rate.
- Deviations from the Phase II Work Plan.

Phase III of the Project consisted of the following four tasks as defined in Section 2.3 of Appendix A to the AOC (EPA, 2016a):

1. Characterization of surface, subsurface soils, and sediment.
2. Characterization (volume) of pits.

3. Streamlined risk evaluations.
4. Waste volumes.

The Phase III FSP covered characterization of the surface and subsurface soils and sediments The Phase III FSP (EA, 2018b) was specific to Phase III work as listed above. Data required to characterize the volume of the mining pits was completed in 2016 with the collection of high resolution Light Detection and Ranging (LiDAR) topographic data for the Site. In addition to the Phase III field investigation, limited field work was performed as a continuation of sampling originated under Phase II. The approved Phase III FSP is provided in Appendix K.

The Phase III Work Plan (EA, 2019c) was specific to the performance of the Phase III work items as defined in Appendix A of the AOC (EPA, 2016a) and listed above. The approved Phase III Work Plan is provided in Appendix L.

The Phase III Summary Report (EA, 2020) documented the methods, results, and evaluation of the tasks outlined in the Phase III Work Plan (approved on September 13, 2019). The approved Phase III Summary Report is provided in Appendix M. The Phase III Summary Report provided a detailed discussion of:

- Vertical profile of soils above investigation level (IL).
- Conceptual on-Site pit volume estimates.
- Human Health Streamlined Risk Evaluations.
- Ecological Streamlined Risk Evaluation.
- Development of volume estimates above the risk based action level (rbAL) and IL.

2.0 SITE SETTING

2.1 Site Location

The project area is located in the Little Colorado River (LCR) Valley in Coconino County, Arizona (Figure 1-1). Areas affected by historical uranium mining west of the LCR on Section 9 and Section 10 of Township 27 North, Range 10 East of the Gila and Salt River Base and Meridian comprise the Site (Figure 2-1). The Site falls within the boundary of the CO Bar Ranch, which is owned and operated by the Respondent, headquartered in Flagstaff, Arizona. Section 9 is owned by the Respondent. A portion of Section 10 on CO Bar Ranch (i.e., the portion west of the LCR) is owned by the Bureau of Land Management (BLM) Reclamation and leased by the Respondent. The Navajo Nation surrounds this general area and is located approximately 10 miles to the west of Section 9, one mile to the north of Section 9, and is on the adjacent Section 10 on the east side. The Navajo Nation owns the eastern majority of Section 10 with the LCR floodplain as the dividing feature between ownership in Section 10. The project Site is not currently used by the Respondent for any purposes involving livestock or human activity. There are no structures or facilities present within the project Site related to any Respondent operations.

The Arizona Department of Environmental Quality (ADEQ) conducted a uranium site discovery project in 2007 (ADEQ, 2007) to identify potential uranium mining impacts in Arizona that might warrant further investigation. This project identified the Section 9 Lease sites. Also, in 2007 the United States Army Corps of Engineers (USACE), EPA, the Navajo Nation Environmental Protection Agency (NNEPA), and the Navajo Abandoned Mine Land Reclamation Program (NAMLRP) issued an AUM Geographic Information System (GIS) Report compiling the findings from earlier investigations of the uranium mining operations throughout the Navajo Nation; the Section 9 Lease sites were identified in the report. The U.S. Environmental Protection Agency (EPA) has identified three abandoned uranium mines (AUMs) that potentially affect the Site: AUM 457, AUM 458, and AUM 459. These are shown on Figure 2-1.

The Site is defined in Section III of the AOC as:

> *"Site" shall mean and include the Section 9 Lease Mine, including Section 9 of Township 27 North, Range 10 East, including the areas depicted in Appendix A, and other areas where hazardous substances from Section 9 have been deposited, stored, disposed of, placed, or otherwise came to be located on Section 10 of Township 27 North, Range 10 East.*

The EPA included the Site in the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) on October 10, 2011 as EPA ID No. NNN000909110 (Weston, 2012).

The three AUMs that potentially affect the Site have been described by the EPA in the AOC as follows:

- *Abandoned Uranium Mine ("AUM") AUM 457 comprises approximately 16.5 acres, is located on the western banks of the Little Colorado River, and is the northern most of the three mining areas investigated by EPA as the "Section 9 Lease Site." AUM*

457 is characterized by a former borrow pit, a former pond, and the remnants of facilities which former operators claimed could upgrade uranium ore, including a clearly visible foundation and partially intact walls. Un-reclaimed mining-related uranium waste rock, and various wood/metal mining-related debris are present within the footprint of AUM 457. … A portion of AUM 457 extends east of the boundary of Section 9 onto Section 10, which is owned by the United States. …

- *AUM 458 comprises approximately 9.3 acres, is located approximately 0.25 miles west of the Little Colorado River, and is the most central of the three mining areas, approximately 0.5 miles south of AUM 457 and 1,000 feet northwest of AUM 459. AUM 458 is characterized by a centralized recessed pit/depression with standing water and vegetation, surrounded by un-reclaimed mining-related uranium waste rock, and various wood/metal mining-related debris. …*
- *AUM 459 comprises approximately 13.3 acres, is located approximately 1,000 feet west of the Little Colorado River[1], and is the southern most of the three mining areas, approximately 1,000 feet southeast of AUM 458 and 0.75 miles south of AUM 457. AUM 459 is characterized by the presence of three pit areas each surrounded by un-reclaimed mining-related uranium waste rock, and various wood/metal mining-related debris. Most, and possibly all, of AUM 459 is located south of the boundary of Section 9 on property owned by the State.*

In addition to the mining features and structures contained within the "approximate mining areas" associated with AUMs 457 and 458, and materials that have come to be located in Section 9 from mining operations in AUM 459 as established by the EPA, Appendix A to the AOC includes these additional "Areas to be Addressed":

- Areas of technologically enhanced naturally occurring radioactive material (TENORM) in the immediate vicinity of the AUMs (step-out areas) at the discretion of the EPA.
- Mine haul roads and shoulders (as defined in EPA, 2016a).
- Little Colorado River riparian corridor (as defined in EPA, 2016a).
- Drainages (as defined in EPA, 2016a).

The currently proposed Area of Potential Effect (APE) is illustrated on Figure 2-1. The APE is the area anticipated to have been impacted or that may be impacted by investigation activities. For purposes of this Project, the eastern Site boundary has been established as 5 meters (15 feet) west of the centerline of the Little Colorado River (further defined as USGS 1969 mapping). Figure 2-1 also presents the approximate boundaries of the mining areas as defined by Weston (2012) and background study areas (BSAs).

[1] The Little Colorado River channel changes with time and the distances provided from the AOC are for reference only.

2.2 Site History

2.2.1 *Land Ownership History*

The land ownership history has been described by the EPA in the AOC as follows:

- *From August 6, 1912 through June 20, 1960, Section 9 was owned sequentially by Babbitt Bros. Lands, Inc. (1921–1954) and CO Bar Livestock Company (1954–1960), subsidiaries of Babbitt Brothers Trading Company, a precursor to Babbitt Ranches LLC.*
- *On June 20, 1960, CO Bar Livestock Company sold Section 9 in an installment sale, conveying title to Arizona Title Guarantee and Trust Company, as Trustee for John and Carolyn D. Haynes, George B. and Mary Cady, and B.T. Investment Corporation. CO Bar Livestock carried back a portion of the purchase price.*
- *… On November 23, 1971, Arizona Title and Trust Company conveyed title of Section 9 back to CO Bar Livestock Company. Through subsequent transactions between related entities, Respondent C.O. Bar, Inc. became the owner.*

2.2.2 *Mining History*

The mining history has been described by the EPA in the AOC as follows:

- *Uranium was first reported in the Cameron area in 1950, and mining ceased by 1963. Mining occurred on Section 9 from 1957 to 1962. In 1957, Arrowhead Uranium, a subsidiary of Rare Metals Corporation of America ("Rare Metals"), leased the rights to Section 9 from CO Bar Livestock Company, and began an open pit mining operation. In the first year, Rare Metals shipped 17.95 tons of low grade ore from the Site to the Rare Metals Mill in Tuba City and paid royalties to CO Bar Livestock Company. By 1958 Rare Metals ceased mining operations at the Site, and C.L. Rankin acquired the lease from CO Bar Livestock Company. C.L. Rankin shipped 87.21 tons of low grade ore in 1958, and 234.32 tons of low grade ore in 1959.*
- *In 1959, Murchison Ventures, Inc. ("Murchison Ventures"), owned by John Milton Addison and others, acquired the lease of Section 9. Murchison Ventures built a small processing plant known as a "Benson Upgrader" in the northeast part of Section 9, near one of the former pits (AUM 457). Murchison Ventures claimed the Benson Upgrader would separate the waste rock from previous mining activities into a "sellable" higher grade slime fraction and a lower grade sand fraction. Murchison Ventures sent a shipment of 10.76 tons of upgraded ore to the Tuba City Mill in 1959. In 1960, Murchison Ventures modified the plant and sent another shipment of 11.31 tons of ore to the mill. John Milton Addison was adjudicated bankrupt on June 27, 1960.[2] On this date, all funds and assets—including the mining lease for the east half of Section 9—of John Milton Addison and various corporate entities with which he was affiliated came under the jurisdiction of the United States District Court for the Northern District of Texas (Dallas). In 1961, John Milton Addison, along with six associates, was* (SIC) *convicted of fraud, conspiracy, and federal security violations related to the upgrading operation.*

[1] *SEC v. John Milton Addison, Murchison Ventures, et al., 194 F Supp. 709 (N.D. Tex., 1961), Page 714.*

- *In October 1960, a group of Addison's investors incorporated as Milestone Hawaii to assume control over the Murchison Ventures operation on Section 9. As noted above, this was after the title to Section 9 was conveyed to Arizona Title and Trust Company in June 1960. During the summer of 1961, Milestone Hawaii demolished the original Benson Upgrader on Section 9 and replaced it with a larger upgrader, and in March 1962 shipped 23.93 tons of low-grade material to the Tuba City Mill.*
- *Mining operations ceased at the Site in 1961; no known mining activities have been performed at the Site since. While operational, the Atomic Energy Commission estimated the uranium ore production volume at the Section 9 Lease Mine, which included all three AUMs, as 386 tons* [AUMs 457 and 458 are located on Section 9 and AUM 459 is located on Arizona state land].

The Benson Upgrader operations were run by John Milton Addison (Chenoweth, 1993). It was stated that the Benson Upgrader could treat 1,000–1,500 tons per day of ore material averaging 0.01–0.03% U_3O_8 and produce 200–300 tons per day of ore material containing 0.25–0.30% U_3O_8 (Chenoweth, 1993).

A 10.76 ton shipment identified as having originated from the CO Bar Livestock Company lease that averaged 0.16% U_3O_8 was shipped to the Tuba City Mill (Chenoweth, 1993).

On December 4, 1959, the trial of John Addison began for theft and violating Texas state securities laws in San Antonio; Addison was acquitted.

In April 1960 the Benson Upgrader was modified and another ore shipment from the Murchison Ventures Mill was sent to Tuba City. This 11.31ton shipment averaged 0.16% U_3O_8 (Chenoweth, 1993).

On May 17, 1960, in a federal action for fraud Addison was indicted by a federal grand jury in Fort Worth, TX, on charges alleging fraud, conspiracy, and violations of federal securities regulations.

On June 15, 1960, fourteen employees at "Cameron Millsite" (i.e., Benson Upgrader) were forced to attend a 7-hour-long meeting by Addison and held there by an armed security guard force. Addison was charged with false imprisonment.

On June 20, 1960, CO Bar relinquished ownership of Section 9. Arizona Title Guarantee and Trust Company assumed a warranty deed as Trustee from CO Bar Livestock Company.

On June 24, 1960, the Arizona Daily Sun reported that on June 23, 1960 Addison and 22 others were arraigned in Flagstaff on a charge of false imprisonment of 14 men at the upgrader site on June 15, 1960.

In June 1960 Murchison Ventures reorganized itself into Milestone Hawaii, Inc. (Chenoweth, 1993). Milestone Hawaii, Inc. was not incorporated until October 10, 1960.

In July 1960 a Texas bankruptcy Court held John Milton Addison's company to be bankrupt (United Sates Court of Appeals Firth Circuit, 1967).

The Arizona Daily Sun reported on August 22, 1960 that Addison's false imprisonment trial began in Flagstaff against Addison et al.

The Arizona Daily Sun reported on August 24, 1960 that, "*William J. Rochelle, Dallas lawyer and co-receiver in Addison's federal bankruptcy case, reported this Tuesday to creditors. Rochelle, who was named a trustee in the case, appeared as creditors met for the first time with bankruptcy referee Elmore Whitehurst. Whitehurst continued the hearing until Sept. 19 when Addison didn't appear to answer further questions about his assets. Addison currently is on trial at Flagstaff"*.

The Arizona Daily Sun reported on August 31, 1960 that on August 30, 1960, Addison et al. were acquitted of false imprisonment charges. Addison said he wanted to get the upgrader in production as soon as possible at the company site near Cameron, the scene of the alleged imprisonment of the 14 men on June 15.

The Arizona Daily Sun reported on May 27, 1961 that on October 10, 1960, Milestone Hawaii, Inc. formed – assets and operations of Milestone Hawaii were subordinated to Wm. J. Rochelle, Jr, the bankruptcy trustee for Milestone Hawaii. A Notice of Incorporation was published for Milestone Hawaii. ARTICLE IX of the Incorporating documents stated: *Each and every stockholder shall be advised that the assets of this corporation and the operation of this corporation, shall be subordinate to the directives of the Trustee [William Rochelle Jr.] in the bankrupt estate of John Milton Addison, aforesaid, and if in the opinion of said Trustee it is unwise for this corporation to exist, and the same shall be terminated prior to the payment of the claims in the said bankrupt estate, then such termination shall be final and neither the officers, directors, or the stockholders shall have any grievances against said Trustee nor shall any of the stockholders have the right to any suit or grievance against any or all of the directors and officers of this corporation."*

The Arizona Daily Sun reported on February 1, 1961 that on January 31, 1961, Trustee Wm. J. Rochelle, Jr. assumed control of the Murchison leases and assets. Addison turned over [leases] to a lawyer for trustee William J. Rochelle, Jr. bankruptcy estate's trustee, a Dallas bankruptcy attorney with Weil, Gotshal and Manges. Addison delivered [the leases] in compliance with a court order, clearing the way for a new non-Addison corporation to take over the operation. *"We have now agreed to the terms of a lease agreement," said Rochelle, "and we will submit it to the court and the creditors for approval." "The new company, Milestone Hawaii Inc., put up $150,000 before Rochelle would consider its proposal. All stockholders in Milestone live in Hawaii. They will operate the mining properties and the Benson upgrader, a device which Addison claims permits profitable mining of otherwise worthless uranium ore. NO PROFIT will be taken out of the new company until Addison's $2 million in debts to creditors and lenders is repaid with interest*," Rochelle said.

On February 17, 1961, Addison and six associates were convicted in a Texas court of mail fraud, conspiracy, and Federal security-law violations (Chenoweth, 1993). Addison purported to own patent rights to the Benson Upgrader, which, with at a total investment cost of $65,000, would produce profits of $86,000 a day and, by upgrading low-grade uranium, would replace a 13 million dollar uranium mill. He represented that he and his associates owned a uranium mine containing 2½ million dollars of uranium. (*United States of America, Appellant v. William J. Rochelle, Jr., Trustee in Bankruptcy for John Milton Addison*, 384 F.2d 748 [5th Cir. 1967]).

In *SEC v. Addison* the United States District Court Northern District of Texas, Dallas Division, June 2, 1961, the court found that Benson Upgraders were unproven and unprofitable.

Addison was sentenced to serve 15 years and pay fines totaling $36,000. See, *John Milton Addison v. United States,* 317 F.2d 808 (5th Cir. 1963). Addison was released on parole in 1971.

The San Antonio Light reported on August 7, 1961 that the original Benson Upgrader was dismantled by Milestone Hawaii. "*Uranium upgrader has been dismantled*", see letter from Naoji Yamagata to San Antonio newspaper and replaced by a new upgrader. *"Initial production of concentrates will be on the order of 50 tons"* Yamagata reported. "*Milestone Hawaii is erecting a completely new, modern plant at the old site near Cameron*," the letter said. "*The new concentrator will treat large low-grade ore reserves on private, public and Navajo Indian land within economic hauling distance of the mill site."* The corporation was formed earlier this year by a group of independent Hawaiian investors to lease the assets of Addison's bankrupt estate. "*The company expects to raise the tonnage to 100 tons daily by early 1962. We expect to produce about 1 ton of concentrate for each 10 tons of ore treated*."

In September 1961, the original Benson Upgrader was replaced with larger one by Milestone Hawaii. Milestone Hawaii officials all reside in Honolulu:

President – Naoji Yamagata
Secretary – Johnny Sakaki
Manager – Leon K. Sterling Jr.

According to Travis P. Lane's Weekly Report TPL WR 9-16-61, the company dismantled the original Benson upgrader constructed by Murchison Ventures and built a much larger and more elaborate one on the same site. Plant design and construction were under the supervision of Page Blakemore. Mining was to be performed on contract by Cameron Mining Co. Properties included sections leased from the CO Bar Livestock Co. (Babbitt) and a section owned by Blakemore. The lands to be worked first were all at or near the plant site. It was anticipated that plant feed would run 0.06–0.07% U_3O_8 and upgraded product 0.50–0.60% U_3O_8 and that the plant would handle around 700 tons per day (tpd). (Travis P. Lane Weekly Report TPL WR 9-16-61 – Item in Arizona Department of Mines and Mineral Resources Mining Collection).

On November 3, 1961, Chenoweth visited the Milestone Hawaii upgrader and talked with Leon Sterlin and Page Blakemore. Chenoweth was told that the new upgrader "*Will get feed from Section 9 and Section 16 where he has a lease."* (Chenoweth notes, 2012). Blakemore had leases to both the Grub #14 area and part of AUM 459 area between August and December 1961.

Neither Sterling nor Milestone Hawaii had any leases in Section 16. Leon Sterlin referred to "*a section owned by Blakemore*," which is problematic because Blakemore was an operator and contractor, not a property owner.

On March 8, 1962, Chenoweth again visited the Milestone upgrader. Chenoweth states that the "*Plant was crushing a small stockpile of material left by Murchison*." (Chenoweth notes, 2012).

According to Chenoweth (1993), in March 1962 Milestone Hawaii shipped 23.93 tons of ore that averaged 0.10% U_3O_8; material that was processed for this shipment came from shallow pits in T27N R10E, Sections 9 and 16 and was labeled Milestone No.1. The upgraded material came from T27N R10E, Sections 9 and 16 (Nos. 71 [Section 9 lease] and 83 [Grub #14 in SW quarter-section of Section 16]) (Chenoweth 1993). According to Chenoweth (2012), "*The 23.93 tons of material shipped in 1962 came from processing waste material left on Section 9 and from an old pit on Section16, an AZ State Lease*." (Chenoweth notes 2012). The shipment went to the Tuba City Mill.

In May 1962, the Tuba City Mill operated by Rare Metals was closed. (Chenoweth, 1993).

In July 1962, Rare Metals merged with El Paso Natural Gas Co. (Chenoweth, 1993).

On May 28, 1963 the Lease, which had been under the supervision and control of the Bankruptcy Trustee, Wm. J. Rochelle, Jr., was released back to Milestone Hawaii. The release was signed by William J. Rochelle, Jr., Trustee in Bankruptcy for John Milton Addison.

On November 23, 1971 CO Bar regained ownership of Section 9 because Arizona Title Insurance Company defaulted on its note held as security by CO Bar Livestock Company. CO Bar Livestock reassumed the warranty deed from Arizona Title Insurance Company.

In his 1993 report, Chenoweth stated in Table 8 that a total of 361.55 tons of ore were delivered to the Tuba City Mill from Section 9 (not including 23.59 tons from Milestone No.1) at an average of 0.12% U_3O_8. The shipments cited above total only 127.32 tons, so 234.32 tons of ore shipped to the mill from Section 9 are unaccounted for in Chenoweth's text. Chenoweth in his 2012 notes identifies a shipment by Rankin in 1959 of 234.32 tons, which is consistent with the total ore shipped.

2.3 Current Conditions

The three AUMs (457, 458, and 459) within and adjacent to Section 9 are described as follows:

- AUM 457 is primarily located on Section 9 but does extend eastward onto Section 10. The western portion of Section 10 from the boundary with Section 9 to the Little Colorado River is owned by the U.S. BLM.
- AUM 458 is located wholly within Section 9.

- AUM 459 is located wholly within Section 16, which is owned by the State of Arizona. Erosional depositions from AUM 459 waste material has encroached onto the very southern portion of Section 9 within the bottom of the drainage.

The Navajo Nation surrounds this general area to the west, north, and east. The eastern majority of Section 10 is on the Navajo Nation with the centerline of the Little Colorado River as the dividing feature between the BLM land and the Navajo Nation Land for Section 10. The Little Colorado River (LCR) floodplain transects Section 10 in a south-north orientation. The LCR flows to the north in this area. Dry drainages (e.g., arroyos, washes) originate within Section 9 and drain eastward, terminating at the LCR floodplain. A playa is located west-southwest of AUM 457.

Shallow mine pits (less than 20 feet deep), waste rock piles, mine access haul roads, and concrete foundations and walls of former mine structures reside on the ground surface in areas where mining took place in Section 9. The gamma radiation level collected by Weston (2014) is provided on Figures 2-2, 2-3, and 2-4. Data for select metals, metalloids and radionuclides are included on Figures 1-2, 1-3, and 1-4.

Section 9 has been deed restricted as of July 22, 2019. Entry upon the property is prohibited pursuant to the deed restriction recorded in Coconino County and is in violation of Arizona trespass law. The deed restriction does not allow any future use of Section 9 with the exception of maintenance of the main access road and inspection of the property. Signs have been posted on Section 9 to notify potential trespassers that the section is deed restricted. The deed restriction is provided in the Phase III Summary Report provided in Attachment M.

As discussed in Section 6.0 and based on the current conditions the following human receptors were evaluated:

- On-Site Adult Worker
- Long Term Adult Recreator (24 years of exposure)
- Child Recreator (2 years of exposure)
- Combined Long Term Adult and Child Recreator (26 years of exposure)

2.4 Ecological Conditions

SWCA Environmental Consultants (SWCA) summarized the land use and ecological setting of the Site as part of their biological resources survey (SWCA, 2016). The climate at the Site is very dry, with temperatures below freezing in the winter (average minimum approximately 21°F) and very hot in the summer (average maximum temperature of approximately 97°F). The average monthly precipitation ranges from 0.33 to 0.91 inch with an annual total of 5.7 inches.

There are two named watercourses on or near the Site: an ephemeral reach of the Little Colorado River (LCR) along the eastern boundary of the Site and Mays Wash located on the south side of the Site. On average, the LCR channel is dry three months of the year. The nearest perennial surface water with any hydrological connection to the Site is the lowest reach of the LCR, which begins approximately 58 miles downstream of AUM 457.

There is vegetation in the riparian habitats along the LCR and Mays Wash, and within drainages and depressions in the upland areas. Vegetation in these areas is degraded by non-native, invasive species including tamarisk. Most of the upland areas are sparsely vegetated by native (e.g., snakeweed, shadscale) and non-native species (e.g., camelthorn). There are only a few cottonwood trees in the area.

As presented in Section 7.0 the following ecological receptors were evaluated:

In the upland areas (e.g., the AUMs) under the Dry and Wet Condition Scenarios the following receptors were evaluated:

- Plants
- Insectivorous mammal: Desert shrew
- Insectivorous bird: Rock wren
- Herbivorous mammal: Deer mouse
- Insectivorous bird: American kestrel
- Carnivorous bird: Golden eagle

In the riparian areas (e.g., along the LCR) Dry and Wet Condition Scenarios the following receptors were evaluated:

- Plants
- Insectivorous mammal: Desert shrew
- Insectivorous bird: Rock wren
- Herbivorous mammal: Deer mouse
- Herbivorous bird: Mourning dove
- Omnivorous mammal: Coyote
- Carnivorous bird: Golden eagle

2.5 Geologic Setting

The Geologic Map of the Cameron Quadrangle (Billingsley et al., 2007) was reviewed to determine the general site geology. The mapped units are shown on Figure 2-5. According to the geologic map, the following Quaternary-aged geologic materials are present at the Site:

1. Terrace deposits (Qgy)
2. Playa deposits (Qps)
3. Alluvial deposits in the Site drainages and in the Little Colorado River floodplain (Qs and Qf)
4. Alluvial fan and eolian deposits (Qay and Qae)
5. Dune sand and valley fill (Qd and Qv)

In the background determination memo from the EPA (2016b), the alluvial deposits (numbers 2-5) were grouped together as Qal. They included the floodplain, stream, Holocene fluvial, and dune deposits. This grouping of the Playa deposits, Alluvial deposits, Alluvial Fan, and Dune sand and valley fill as Quaternary Alluvium (Qal) was determined to be appropriate and was used for the Project.

In addition, both mineralized and unmineralized outcrops of the Chinle Formation (Petrified Forest [TRcp] and Shinarump members [TRcs]) are present at the Site. Uranium mineralization occurs in a thin zone of the Shinarump member where exposed in the mine pits in the AUMs (EPA, 2016b). Outcrops are considered naturally occurring radioactive material (NORM).

As part of the Background Study for the Phase II work, a Desktop Survey (EA, 2018a) was completed. The Desktop Survey was used to scope the areal extent of the Background Study. As part of the Desktop Survey, aerial photographs along with the geologic map (Billingsley et al., 2007) were used to confirm the locations and areal extent of the dominant geological/pedological units potentially impacted by uranium operations at the Site. In general, the geology noted in the Billingsley et al. (2007) map matches what is shown in the aerial photographs. However, supplementary geologic mapping in the vicinity of AUMs 457 and 458 was completed as part of the Field Reconnaissance portion of the Background Study. The results of this supplementary mapping are presented in the Phase II Summary Report (provided as Appendix J to this report). The additional geological mapping was needed in the areas of the AUMs and Background Study Areas (BSAs) to account for local inaccuracies of the existing Billingsley et al. (2007) geologic mapping.

The geologic mapping from Billingsley et al. (2007) was also overlain over the aerial radiological survey that was completed in 1997 (Bechtel Nevada, 2001). There does not seem to be a strong correlation in the Project area between the radiological survey results and the geologic units.

2.6 Physical Conceptual Site Model

The three EPA-identified AUMs (457, 458, and 459) within and adjacent to Section 9 along with other Site features are shown on Figure 2-6. Site details for each AUM are discussed below.

2.6.1 *AUM 457*

Figure 2-7 presents the EPA-identified AUM boundary, EPA-identified drainage area boundary, EPA-identified "Wetland 3," EPA-identified road centerline and buffer, and other mine related disturbances for AUM 457. These mine related features include mine pits, the upgrader area, and other areas of mine waste. AUM 457 was accessed by a set of roads over which ore was hauled to off-site uranium mills. Aside from the primary site access road, numerous tracks have been left by vehicles traveling the area over many decades, not all of which relate to mining activity. Mining activities at AUM 457 included excavation of shallow mine pits from which ore was removed, and the generation of waste rock piles where overburden, gangue, and low-grade mineralized rock was moved and stockpiled (waste rock areas). Ore removed from AUM 457 pits or delivered from other Section 9 Lease AUM pits was stockpiled on the bluff west of the LCR floodplain area (ore stockpile area).

The upgrader system was installed east of the ore stockpiles off the bluff to take advantage of the elevation difference and use the gravity-driven potential energy to assist the hydraulic sorting of the ores by the upgrader (upgrader area). Granular and liquid waste from the upgrader was discharged to the land surface west of the LCR. The upgrader area currently includes concrete foundation walls and on-grade slabs, though essentially all the metal and wooden components of

the system have been removed. Some wood and metal scrap from mine related structures remain littered across the Site.

Figure 2-7 shows four areas (Northern Drainage, Pond Area, Upgrader Area, Bedrock Ridge West of AUM 457) with indication of the general flow direction of surface water near AUM 457. The Northern Drainage flows from the playa area towards the Little Colorado River. This drainage has only minimal sources of mining wastes, and has no indication of historic transport of mine waste above IL levels into Section 10. Material migration is not considered likely for this drainage area. The Pond Area shows that drainage from the pond berm is directed into the pond. This drainage is self-contained and material migration is not considered likely for this drainage area. The Upgrader Area drains from the upgrader to the east towards the LCR. There is evidence of erosion from the upgrader area down the drainage to the bank of the LCR in Section 10. The depth of the alluvial deposit from this erosion varies from 1 foot to 5 feet in the drainage. The Bedrock Ridge drainage shown Figure 2-7 shows drainage to the west off of the ridge west of the upgrader to the Playa. There has been no indication of historic transport of mine waste above IL into the LCR from this drainage area. A more detailed discussion of the material migration and flow from these drainages is provided in more detail in Section 5.6.1.

2.6.2 *AUM 458*

Figure 2-8 presents the EPA-identified AUM boundary, EPA-identified drainage area boundary, EPA-identified drainage network, EPA-identified road centerline and buffer, and other mine related disturbances for AUM 458. Based on the maps included in the AOC, AUM 458 was accessed by a single mine road from the north, ore was hauled either directly to a mill or to the upgrader at AUM 457 over this road. Aside from the primary site access road, numerous blade cuts and tracks have been left by mining activity. Mining activities at AUM 458 included the excavation of shallow mine pits from which ore was removed, and generation of mine waste. Ore removed from AUM 458 pits was stockpiled and either hauled directly to a mill or to the upgrader at AUM 457. TENORM may be present along haul roads as ore may have spilled along the road alignments during transport. There is also the potential that the haul roads may have been cut through outcrops that have gamma readings above the statistical background average. General traffic unrelated to mining activities may also have dislodged rock that contains uranium.

Review of Figure 2-8 shows four areas (within AUM 458, outside AUM 458, ridge south of AUM 458, drainage south of AUM 458) with the general direction of surface water flow indicated. Figure 2-8 indicates that drainage from the inside of the pit is directed to the bottom of the pit. Potential flow is from the crest of the pit into the pit bottom. This drainage is self-contained and material migration is not considered likely for this drainage area. The area outside of the pit capture area, but within AUM 458 boundary is shown on Figure 2-8. This area flows radially away from the pit capture area. The surface gamma surveys outside of the pit capture area are generally less than two times IL as shown on Figure 4-14. There is evidence of erosion from the area, gamma survey data indicate the material has not historically migrated very far, and thus the potential for off-Site contamination is low. There is an area of exploration along the ridge south of AUM 458. The runoff from this ridge generally flows to either the west or east. There is limited evidence of erosion from this area to the west and east. However, the gamma surveys in the NORM areas surrounding this feature are below the IL as shown on Figure 4-14.

Therefore, while there is evidence of erosion from the area, gamma survey data indicate the material has not historically migrated very far, and thus the potential for off-Site contamination is low. There is a large drainage south and east of AUM 458. This drainage flows from the west in an easterly direction to the LCR. The drainage flows between AUM 458 and AUM 459 as shown on Figure 2-8. There is an area that is up to two times the IL in the finger drainage immediately north of AUM 458, however, downgradient of this area the gamma levels are below IL. Therefore, while there is evidence of erosion from the area, gamma survey data indicate the material has not historically migrated very far, and thus the potential for off-Site contamination is low. A more detailed discussion of the material migration and flow from these drainages is provided in more detail in Section 5.6.2

2.6.3 *AUM 459*

Figure 2-8 presents the EPA-identified AUM boundary, EPA-identified drainage area boundary, EPA-identified drainage network, EPA-identified road centerline and buffer, and other mine related disturbances for AUM 459. Figure 2-8 includes the portion of AUM 459 within the Section 9 Lease site and not the portion within adjacent Section 16. Pursuant to the AOC, mine related features to be addressed in this and subsequent phases of work are limited to a single mine access road and a section of drainage that is downgradient from Section 16 mining disturbances. Inspection of Site imagery indicates that there are no visible mining-related disturbances related to AUM 459 in Section 9 other than the mine access road. The Weston SI Report (Weston, 2014) identified the northern extent of AUM 459 as extending into Section 9. Ore removed from AUM 459 pits in Section 16 was either hauled directly to a mill or to the upgrader located at AUM 457.

Review of Figure 2-8 shows two areas (drainage north from AUM 459, drainage northwest from AUM 459) with the general direction of surface water flow indicated. The drainage that flows northeast from AUM 459 to the LCR combines with two additional drainages before they enter the LCR floodplain as shown on Figure 2-8. There is evidence of erosion from AUM 459 into the drainage in Section 9. The material decreases in gamma values from the AUM 459 boundary downgradient to the road, but remains above the IL the entire distance. The alluvium below the road is below the IL until it enters the LCR floodplain. There is the potential for this elevated material to migrate into the LCR floodplain during larger storm events. There is a large drainage northwest of AUM 459. This drainage flows from the west in a northerly direction to the LCR. The drainage flows between AUM-458 and AUM 459 as shown on Figure 2-8. The surface gamma surveys of the drainage southeast and downgradient of the AUM 458 area are shown on Figure 4-11 and show the gamma levels below IL. While there is evidence of erosion from the area, gamma survey data indicate the material has not historically migrated very far, and thus the potential for off-site contamination is low. A more detailed discussion of the material migration and flow from these drainages is provided in more detail in Section 5.6.2

3.0 INVESTIGATION WORK PLANS

The three phases of work included in the AOC (EPA, 2016a) were Phase I: Cultural Resources Surveys, Biological Survey and Signage; Phase II: Background Determination and Gamma Scanning; and Phase III: Removal Site Evaluation. As required by the AOC, prior to initiating work on each phase a Work Plan was developed for EPA review and approval. The Phase I, II, and III Work Plans (EA, 2017a, 2017e, 2019c) are included with this report as Appendices G, I, and L. Field activities in support of completion of the phases of work included site mapping, gamma radiation scanning, concrete surface activity surveying, surface soil sampling, and subsurface soil sampling. This section outlines the field sampling methods used for the field work performed for the Site. Field sampling methods are further defined in the Phase II (EA, 2017d) and Phase III (EA, 2018b) Field Sampling Plans which are included with this report as Appendices D and K, respectively.

3.1 Site Mapping

Site mapping was conducted to inform the first task in the Phase II work – the Background Study. The purpose of the Background Study was to identify potential background study areas (BSAs) and, once these areas were approved by the EPA, establish background levels in soils and sediments for gamma emissions and preliminary descriptive statistics for PCOCs in areas not impacted by TENORM. The background levels are intended to support establishing investigation levels (IL), as defined in Section 1.3 of the SOW. Per the Phase II Work Plan, the background study was divided into the following subtasks:

- Desktop survey
- Background study area (BSA) selection
- Field reconnaissance and gamma scan

3.1.1 *Desktop Survey*

The following data and information sources were reviewed during the Desktop Survey:

- Aerial photography (various sources).
- Topographic mapping (various sources).
- Historic aerial radiometric data (Bechtel Nevada, 2001).
- Gamma survey data from the prior investigations (Weston, 2012 and 2014).
- Analytical data from soil samples collected in the SI investigation (Weston, 2014).
- Geologic mapping (USGS, 2007).
- Soils mapping (Soil Conservation Service, 1983).

3.1.2 *BSA Selection*

The BSAs for soil sampling were selected with the general intent of being considered appropriate background reference areas (BRAs) such that the background data collected from the BSA is reasonable and appropriate if not entirely sufficient for use as background when assessing Final Status Surveys data. The Desktop Survey included selecting BSAs for the alluvial and terrace deposits. In addition, BSAs were selected for drainage areas and the LCR corridor. It was determined that while the geology in these areas is similar to the overall

geology, the depositional characteristics are such that these areas should have a representative BSA also.

In conformance with the Phase II Work Plan, provided in Appendix I of this report, the following criteria were considered during the Desktop Survey to identify potential BSAs:

- Geological materials in the BSA shall have similar physical, chemical, geological, radiological, and biological characteristics as encountered in the AUM and likely step-out areas being evaluated per the Multi-Agency Survey and Site Investigation Manual (MARSSIM) Section 4.5 (EPA, 2000), as determined by appropriate experts.
- The BSA shall be selected with the objective that the radioactivity present in a BSA would be ideally the same as the comparable geological material in the AUM and likely step-out areas had they never been contaminated, per MARSSIM Section 4.5 (EPA, 2000), as determined by appropriate radiological experts.
- The BSAs shall not be potentially contaminated by Site activities and shall not be part of the AUM and likely step-out areas being evaluated. Therefore, BSAs shall be upwind and upgradient of the AUM and likely step-out areas being evaluated.
- It is the project goal to find appropriate BSAs with no anthropogenic disturbance or TENORM. If no appropriate undisturbed BSA can be located, a BSA with disturbance that is demonstrably not mining related and is upwind may be selected as a reasonable BSA location.
- BSAs should be selected for each geologic unit or material anticipated in the AUM and within the likely step-out areas being evaluated.
- BSAs shall be void of culturally sensitive locations.
- BSAs shall be contiguous 0.5 acre areas or other appropriate sizes.

3.1.3 *Field Reconnaissance*

After the Desktop Survey was completed, a Field Reconnaissance was performed from September 12-14, 2017, in general conformance with the guidance provided in the Phase II Work Plan (EA, 2017e). The field reconnaissance included representatives from EA, C2 Environmental, EPA staff, and Weston Solutions (EPA-Contractor). During the field reconnaissance, the BSA boundaries were adjusted to avoid anthropogenic disturbance and to better align with selected geologic features. These field adjustments were agreed to by all present in the field.

In addition to confirmation of the BSA locations, the field reconnaissance was also used to confirm locations of mining-related TENORM and to perform geologic mapping of AUM 457 and AUM 458.

3.2 Gamma Radiation Survey

3.2.1 *BSA Gamma Survey*

The seven background study areas discussed in the Desktop Survey section along with the "Qter BRA" proposed by the EPA (EPA, 2016b) were characterized (Figure 3-1). The BSAs were selected for study because they are unimpacted by mining and are generally representative of Site conditions within the Area of Potential Effect (APE). Figure 3-1 depicts the selected and approved BSA locations. Characterization of the BSAs consisted of:

- A scanning gamma radiation (gamma) survey, which occurred October 19-25, 2017.
- Soil samples and static gamma measurements, collected October 24-27, 2017 (discussed in Section 3.4).

Environmental Restoration Group, Inc. (ERG) conducted a mobile gamma survey of each BSA using a Model 44-20 three-inch by three-inch sodium-iodide detector paired with either a Ludlum Model 4612 multi-zone single channel analyzer or a Model 2221 ratemeter. The AOC SOW (paragraph 1.3) required a scanning minimum detectable concentration (MDCscan) of half of the IL for radium-226 (Ra-226) in soil of 1.24 pCi/g plus background with the gamma detector. A background of 1 pCi/g was assumed. A Ludlum model 44-20 detector was required since the more commonly used Ludlum model 44-10 is not sensitive enough to meet this requirement. This is in agreement with the approved Phase II Workplan. The instruments were function-checked before and after each day of use using a cesium-137 radiological check source. The Model 4612 array's single channel analyzer was operated in open mode, without a region of interest, thus the reported result is a true gross gamma count.

The responses of instruments used for more than one day were tracked for consistency over the course of the gamma survey. Tracking proceeded as follows: prior to use in the field, ten initial quality control (QC) function check values were recorded for each instrument and each subsequent function check was compared to a range of the instrument's initial QC ten count average plus or minus 20 percent. Most of the function check results were within 10% of the established baseline, and none exceeded the 20% limit specified in the workplan. On a few dates, instrument high voltages were adjusted to provide a check that the potentiometer was functioning within its tolerance. Instrument calibration and function check forms are included in the Phase II Summary Report provided in Appendix J of this report.

The gamma survey in the BSAs was conducted using the method described in Section 5.1.2 of the Phase II Work Plan (EA, 2017e). During gamma scanning of the BSAs no signs of disturbance were noted. The BSA locations showed no signs of alteration of conditions from those seen and discussed with the EPA and Weston during the site field reconnaissance. The results of the BSA gamma survey are discussed in Section 4.0.

3.2.2 *Transect Gamma Survey*

The purpose of the transect gamma survey was to characterize the range of gamma radiation levels in areas impacted by Section 9 Lease mining. Mine related disturbances were identified during the desktop and field reconnaissance portions of the background study. The gamma transect scanning was used in delineating the areal extent of mining-related TENORM at the

Site. To achieve this objective, GPS-based gamma-ray scans (gamma survey) were conducted over the Areas to be Addressed as presented in the Scope of Work provided in the Phase II Work Plan (EA, 2017e). The gamma scanning trends were used for the delineation. The areas were divided into the following four types of features:

- Transect gamma survey of AUM areas.
- Handheld gamma survey of upgrader foundation.
- Transect gamma survey of EPA drainage areas.
- Transect gamma survey of other mine related disturbance.

Details of survey methods are provided in the Phase II Work Plan (provided as Appendix I of this report) and discussed in Section 4.4.

3.3 Concrete Surface Activity Survey

An upgrader foundation is located in AUM 457 as discussed in Section 2.6. The upgrader foundation was surveyed on November 6-7, 2017 using direct (static) measurements to quantify alpha and beta surface activity per unit area. Static measurements were made on one-meter square grids of accessible floor and wall surfaces.

3.4 BSA Sediment and Soil Sampling

Soil and sediment samples were collected from BSAs to define background levels of the PCOCs. Soil and sediment samples were collected from the upper 15 cm (0 to 6 inches) of these materials. Samples were collected from October 24-27, 2017, and additional samples were collected from December 3-6, 2018.

The Phase II Work Plan (provided as Appendix I to this report) contains a memorandum that describes the technical basis for the estimated number of background samples to be collected from the BSAs for sample adequacy. The discussion of the sample collection and results is presented in Section 4.5.

The soil and sediment samples were collected, described and documented as outlined in the Field Sampling Plan (provided as Appendix H to this report). Static gamma survey readings (single point readings) were collected at each BSA soil/sediment sample location.

3.5 Surface and Subsurface Soils and Sediment Sampling

Phase III of the Project included characterization of surface, subsurface, and sediment for the Site. The field investigation for this work was conducted at the Site from December 3 through December 6, 2018. The Field Investigation was performed in general conformance with the guidance provided in the Phase III Work Plan (EA, 2019c) and was intended to complete Task 1 (Characterization of Surface, Subsurface Soils, and Sediment) as presented in Section 5.0 of the Phase III Work Plan. The Phase III Work Plan was approved in two parts. Sections 1.0 through 5.3 and Sections 5.6 to 9.0 were approved on November 16, 2018. The Field Investigation was performed under the guidance of those approved sections. The remaining sections (5.4 and 5.5) were approved on September 13, 2019.

The Field Investigation program that was conducted at the Site generally included excavation of test pits and collection of soil and sediment samples with depth. The investigation is described in Section 4.4.4.

4.0 FIELD INVESTIGATION

4.1 Desktop Survey

A Desktop Survey was completed as part of the Background Study. The complete results of the Desktop Survey are included in Appendix A of the Phase II Summary Report (EA, 2018). The objective of the Desktop Survey was to support robust scoping of the Phase II Background Study and Transect Gamma Scan Study. This objective was met by using the available information to identify distribution of the geological materials present at the Site, describe the estimated extent of mining-related disturbances at the Site, review the Background Reference Areas (BRAs) proposed by the EPA (2016b), and develop potential BSAs to evaluate in the field. To complete the objectives, relevant data sources and information were reviewed, including aerial photographs, geologic and soils mapping, historic aerial radiometric data, previous site assessments, and topographic and LiDAR data.

4.2 BSA Selection

One objective of the Desktop Survey was to select BSAs for each of the dominant geological/pedological units identified at the Site for gamma scanning and soil sampling. The BSAs for soil sampling were selected with the general intent of meeting the requirements of the Multi-Agency Survey and Site Investigation Manual (MARSSIM) (EPA, 2000) to be considered as appropriate Background Reference Areas (BRAs). Thus, the background data collected from the BSA is reasonable and appropriate if not entirely sufficient for use as background when assessing Final Status Surveys data. The Desktop Survey included selecting BSAs for the alluvial and terrace deposits. In addition, BSAs were selected for drainage areas and the LCR corridor. It was determined that while the geology in these areas is similar to the overall geology, the depositional characteristics are such that these areas should have a representative BSA also.

In addition, on October 26, 2016, the EPA issued a technical memorandum identifying potential background reference areas (BRAs) for the Site (EPA, 2016b). Consequently, although the background areas are called BRAs in EPA report (2016b) and BSAs in this report both are consistent with the eventual selection of BRAs. The EPA proposed BRAs consisted of one Terrace deposit location ("Qter BRA"), one Shinarump Member location ("TRcs BRA"), and one location in alluvial deposits ("Qal BRA").

The BSAs from the Desktop Survey are presented on Figure 3-1.

4.3 Field Reconnaissance

The Field Reconnaissance was performed to meet the following objectives:

1. Confirmation of proposed BSA locations.
2. Confirmation of mining-related TENORM.
3. Geologic mapping of AUM 457 and 458.

During the Desktop Survey, seven potential BSA locations were selected: two in the alluvial deposits, two in the terrace deposits, two in the drainage areas, and one in the LCR deposits. During the Field Reconnaissance from September 12 through 14, 2017, all seven sites were visited and observed along with two of the EPA proposed BRAs. The EPA alluvial BRA was not

accessible due to dense vegetation and was therefore not visited during the Field Reconnaissance. New sites were proposed in the Field Reconnaissance report Appendix A of the Phase II Summary Report (provided as Appendix J to this report) along with justification for their location. One of the drainage areas (Drainage #1 BSA) was removed from analyses due to concern by the EPA for the potential TENORM impacted material in the BSA area. Gamma scanning was performed and soil samples were collected from Drainage #1 BSA at the EA team's choosing to help quantify the soils that contribute to the drainage in question. The data collected from Drainage #1 BSA was included in this report for completeness. However, it was not used in any calculations or to draw any conclusions presented in this report. The locations of the BSAs are shown on Figure 3-1. Gamma scanning included the seven sites along with a slightly modified Qter BRA location as proposed by the EPA (2016b). Site features identified at each AUM are provided on Figures 2-6 through 2-8. In addition, geologic mapping was performed for AUMs 457 and 458 and is presented on Figure 2-5.

4.4 Gamma Survey

4.4.1 *BSA Scanning*

A summary of the gamma count rate within each BSA is presented in Table 4-1. BSA gamma surveys were completed October 19-25, 2017. The gamma count rates ranged from 19,679-89,067 counts per minute (cpm). However, at the request of the EPA some gamma count rates at the edge of the BSA were removed from the BSA areas due to concern that these areas might have been impacted by mineralization or TENORM. Thus, the resulting range of gamma count rates is 19,679-56,560 cpm. The removal of these data points is discussed in the memorandum provided in Appendix C of the Phase II Summary Report (provided as Appendix J to this report). The results of the gamma survey for each approved BSA are shown on Figures 4-1 through 4-7. A detailed review of the collected data was completed and potential outliers were reviewed for potential removal from the data set. It was concluded that there were no data outliers. A complete statistical analysis of the soil and mobile gamma data, including identification of potential outliers, is provided in Appendix C of the Phase II Summary Report (provided as Appendix J to this report).

4.4.2 *Area of Potential Effect Scanning*

4.4.2.1 APE Scanning 2017

A GPS-based gamma survey was conducted across the entire APE intermittently between October 16, 2017 and November 11, 2017. Results of the mobile gamma survey are shown on Figures 4-8 through 4-12. Figures 4-15 through 4-19 present the results in counts per minute. The transect spacing for the gamma survey was varied per area as follows:

- Three-foot transects within the AUM boundaries (100 percent coverage).
- Six-foot transects within the mine disturbance areas.
- Twelve-foot transects within the drainage areas; or throughout the thalweg with 12-foot transects out to an elevation change of no less than two feet if the thalweg could be visibly verified.

- Fifteen-meter (approximately 45 feet) transects within the remaining non-surveyed area of the APE. The decision was made on November 6, 2017 to complete 15-meter transects within the remaining APE regardless of potential step-out thresholds.
- All areas were surveyed at a speed between 0.5 to 1.0 meters (approximately 1.5 to 3 feet) per second, with the detector approximately 0.5 meter above the ground surface.

The array scanning surveys were conducted using three Ludlum Model 44-20 three-inch by three-inch sodium-iodide high-energy detectors paired with a Ludlum Model 4612 multi-zone single channel analyzer. The backpack scanning surveys were conducted using a Ludlum Model 44-20 paired with a Ludlum Model 2221 ratemeter single channel analyzer. Table 4-2 lists the radiological instrumentation used in the gamma survey by model and serial number. The Model 4612 single channel analyzers were operated in open mode, without a region of interest, thus the reported result is a true gross gamma count.

The responses of instruments used for more than one day were tracked for consistency over the course of the gamma survey. To demonstrate consistency, instruments were function-checked before and after each day of use using a cesium-137 radiological check source. Tracking proceeded as follows: prior to use in the field, ten initial quality control (QC) function check values were recorded for each instrument and each subsequent function check was compared to a range of the instrument's initial QC 10 count average plus or minus 20 percent of the net detector response. Most of the function check results were within 10% of the established baseline, and none exceeded the 20% limit specified in the workplan. On a few dates, instrument high voltages were adjusted to provide a check that the potentiometer was functioning within its tolerance. Instrument calibration and function check forms are included in Appendix B of the Phase II Summary Report (provided as Appendix J to this report).

4.4.2.2 APE Scanning 2020

The equipment used to perform scanning during the Phase II field work could not quantify gamma count rates above 999,960, which is less than upper end of the material that was encountered at the Site. Thus, additional gamma scanning within the AUM was conducted on March 10, 2020 to obtain measurements of gamma above the previous upper limit. The additional gamma scanning followed the procedures and protocols approved in the Phase II Work Plan dated September 6, 2017 (provided as Appendix I to this report). Gamma scanning was completed consistent with Section 5.2.1 and 5.1.4 of the Phase II Work Plan. Ludlum Model 44-20 3-inch by 3-inch sodium iodide high energy gamma-radiation detectors, coupled to a Ludlum Model 2221 with firmware version 26102N13 that provides counts per minute (cpm) and counts per second (cps) output, as presented in Table 4-2. Count rate and scaler (counts integrated over second) data were collected every second. All areas were surveyed at a walkover speed between 0.5 to 1.0 meters per second, with the detector approximately 0.5 meter above the ground surface. Field personnel walked through the supplemental scanning areas carrying the GPS and ratemeter instrumentation in a backpack while holding the detector. As described in the Phase II Work Plan, this scanning protocol results in a scanning minimum detectable concentration (MDC_{Scan}) of approximately 1 picocurie per gram (pCi/g), which meets the required MDC_{Scan} of half the IL, as specified in Section 1.3 of the SOW. The results of the horizontal scanning are shown on Figures 4-13 and 4-14. Instrument calibration and function

check forms are provided in Appendix H of the Phase III Summary Report (provided as Appendix M to this report).

4.4.3 *Concrete Surface Activity Measurements*

The survey of the upgrader foundation consisted of direct (static) measurements of alpha and beta surface activity per unit area collected on November 6-7, 2017. Static measurements were made on one-meter square grids of accessible floor and wall surfaces. The measurements were made using Ludlum Model 43-93 detectors paired with Ludlum Model 2360 ratemeter/scalers. Table 4-3 describes the instrumentation used for the survey. All static measurements were made in the center of an area no greater than one square meter. At the end of the count, the alpha and beta measurement were recorded and the scanning area was photographed.

ERG classified the locations to be surveyed into 13 groups: Bottom Wall (BW), Cement Box (CB), Highest Slab (HS), Lower Block (LB), Lower Slab (LS), Rear Slab (RS), Small Corridor (SC), Small Wall (SW), Top Northern Slab (TNS), Top Slab (TS), Upper Wall (UW), Upper West Block (UWB), and West Wall (WW). Results of the upgrader foundation survey and photographs of the corresponding grid locations are presented in Appendix H of the Phase II Summary Report (provided as Appendix J to this report).

Figures 4-20 and 4-21 are Tukey-style boxplots of surface activity per unit area (alpha and beta, respectively) classified by the survey group.

Surface of the concrete is an initial screen and not a final status survey for free release. Babbitt Ranches is cognizant that the upgrader remnants are related to former mining activities. The deed restriction prohibits entry onto the Site. In furtherance of this prohibition No Trespassing signs have bene posted and Babbitt Supports removal of the upgrader remnants. A final determination on the status of the upgrade remnants will be made in consultation with EPA. Thus, no further characterization of the upgrader foundation is warranted at this time.

4.4.4 *Subsurface Gamma Profiling*

The test pit gamma scanning was completed from December 3 through December 6, 2018. The test pit excavation and gamma survey generally included the following tasks:

- Excavation of test pits with hand auger and/or backhoe at 21 locations.
- Collection of soil and sediment samples at 6 inch intervals.
- Quantification of gamma emissions of each 6 inch soil fraction.
- Determination of the contact between disturbed material and the underlying undisturbed material.
- Determination of samples for analyses of PCOCs and delivery of the samples to ALS Environmental Laboratories (ALS) in Fort Collins, Colorado for analyses.
- Geotechnical analyses of grain size for use in the Streamlined Human Health Risk Evaluation.

Sample location selection rationale are presented in Table 4-4. The locations of the test pits with the gamma survey results are shown on Figures 4-22 through 4-28. These test pits were excavated in 6-inch intervals to a depth ranging from 0 to 7 feet to expose the surface and

subsurface soils, and sediments. Test pits TP-10 and TP-13 were excluded due to the presence of bedrock at the surface. A letter report, dated February 28, 2019, documenting the field investigation was provided to the EPA (EA, 2019b). The EPA issued an e-mail response on May 22, 2019 indicating that they had no questions or comments regarding the field memo. The letter report is provided in Appendix B of the Phase III Summary Report (provided as Appendix M to this report).

Consistent with the approved Phase III Work Plan, the gamma emissions of each 6-inch fraction were quantified at the surface using a 60-second static measurement on a 1 liter Marinelli beaker of soil, using a shielded Ludlum 44-10 2-inch by 2-inch sodium iodide detector coupled with a Ludlum Model 2221 scaler/ratemeter. The 2-inch by 2-inch sodium iodide detector was selected for its compatibility with the Project's Marinelli beakers and shield. Samples were typically counted within one hour after collection. No spectral analysis was conducted in the field. Table 4-5 lists the radiological instrumentation used to make the gamma measurements by model and serial number. Instrument calibration and function check forms are included in Appendix C of the Phase III Summary Report (provided as Appendix M to this report). A summary of the gamma measurements is presented in Appendix B of the Phase III Summary Report (provided as Appendix M to this report). The maximum gamma emission rate for each test pit is presented on Figure 4-17.

4.5 Soil Sampling

4.5.1 *Surface Soil Sampling*

4.5.1.1 2017 Data Collection

ERG conducted soil sampling on the Site in support of the transect gamma scanning and background studies as described in the Phase II Work Plan (EA, 2017e). This work was performed under the guidance and requirements provided in the Phase II Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP) (provided as Appendices H and F, respectively, to this report). Weston Solutions (EPA-contractor) was present in the field during sample collection to provide oversight. Soil and sediment grab samples were collected from the top 15 cm of material (0-6 inches) throughout each of the seven BSAs on October 24-27, 2017. Samples were collected on a triangular grid starting from a random coordinate (EA, 2018a). The soil samples were successfully collected at the selected locations and no adjustments were needed to account for vegetation or other debris. ALS in Fort Collins, Colorado analyzed the soil samples for Ra-226 and six other PCOCs as presented in Table 4-4. This is consistent with the approved Phase II Work Plan. The soil sample results are provided in Appendix D of the Phase II Summary Report (provided as Appendix J to this report). Tables of soil and static gamma data are provided in Appendix E of the Phase II Summary Report (provided as Appendix J to this report). A complete statistical analysis of the soil and mobile gamma data, including identification of potential outliers, is provided in Appendix C of the Phase II Summary Report (provided as Appendix J to this report).

The number of samples collected in each BSA and summary of the Ra-226 analytic results are presented in Table 4-7. Figure 4-29 depicts the Ra-226 soil sampling data in a Tukey-style boxplot. The concentrations of Ra-226 within the BSAs range from 0.55 to 5.43 picocuries per

gram (pCi/g). The Ra-226 concentrations for each soil sample location within the BSAs are shown on Figures 4-30 through 4-36.

The soil samples were also analyzed for arsenic, mercury, molybdenum, selenium, uranium, and vanadium. The analytical results are summarized in Tables 4-8 through 4-13 and Tukey-style boxplots for each metal are shown on Figures 4-37 through 4-42. The metals results for each soil sample location within the BSAs are shown Figures 4-43 through 4-49.

A direct gamma measurement was also made at each soil sample location. ERG used a Ludlum Model 44-20 3-inch x 3-inch NaI (Tl) scintillation detector (serial #271435) paired with a Model 2221 ratemeter/scaler (serial #051517N) for making direct measurements of gamma activity. The instruments were function-checked before and after each day of use using a cesium-137 radiological check source.

4.5.1.2 2018 Data Set Supplement

Additional BSA soil samples were collected in 2018 to supplement the soil samples collected as part of the Phase II work. These soil samples were collected in conjunction with the Phase III field work and consisted of the following:

1. The collection of additional soil/sediment samples with analysis of PCOCs to further evaluate the relationship between the metals/metalloids and Ra-226, using gamma count rate as a surrogate for Ra-226. Those samples were collected from the test pits and the results are discussed in Section 5.0.
2. The collection and analysis of additional soil/sediment samples in the Alluvial BSA #1 and Drainage BSA #2 pools to complete the characterization of PCOCs for these BSAs.

The field team, with EPA concurrence, determined that additional samples from Alluvial BSA #1 could not be collected in a representative area, thereby forgoing additional sample collection. Five additional samples (D207 through D211) were collected from Drainage BSA #2 at locations independent of those selected in Phase II. The original and additional sample locations in the Drainage BSA #2 are shown on Figure 4-34. These additional samples, combined with the samples collection in Phase II, will meet the number of samples proposed in the Phase II Work Plan (EA, 2017e).

Soil samples were collected from the upper 6 inches (0 to 6 inches) of the planned background sampling locations and described and documented according to the requirements of the Phase III Field Sampling Plan (provided as Appendix K to this report). The additional sample locations in Drainage BSA #2 were laid out on a random-start triangular grid using Visual Sample Plan. Combining the Phase II and Phase III samples results in 11 samples total from Drainage BSA #2. This total number of samples is enough to statistically determine the PCOC populations in these two BSAs. The overall approach for this assessment was to aggregate the background data into meaningful data populations based on geological material type or lithology, and estimate the number of background data samples needed for the objective that the average concentration that accurately represents the true background average to within ± 20% at the 95% confidence level per NUREG-5849 (NRC, 1992) as presented in the Phase II Work Plan provided in Appendix I of this report

A summary of analytical results for the Drainage BSA #2 samples from Phases II and III is presented in Table 4-14. Figure 4-50 depicts soil concentrations for PCOCs in Tukey-style boxplots. The concentrations of Ra-226 within Drainage BSA #2 ranged from 0.94 to 1.71 picocuries per gram (pCi/g). The samples used as original sample data are identified in Table 2 the Phase III Soil Sample Data Verification and Validation Technical Memorandum (Appendix D.1) of the Phase III Summary Report (provided as Appendix M to this report).

A direct gamma measurement was also made at each Drainage BSA #2 sample location. ERG used a Ludlum Model 44-10 2-inch by 2-inch NaI (Tl) scintillation detector (serial #PR355764) paired with a Model 2221 ratemeter/scaler (serial #262347) for making direct measurements of gamma activity. The instruments were function-checked before and after each day of use with a cesium-137 radiological check source. For radionuclides, all laboratory-reported values were used to calculate background summary statistics. For metals data sets with values not reported above the reporting limit (non-detects), the minimum detectable limit (MDL) was reported as the sample result to calculate background summary statistics.

4.5.2 *Subsurface Soil Sampling*

Following the gamma analysis discussed in Section 4.4.4, the soil from each sampled interval was placed in a new clean individual sample jar, supplied by ALS, for shipment to EA's office.

Forty-four discrete samples were determined to be representative of the range of gamma count rates obtained in the field and were submitted to the lab for testing. A discussion of this approach is provided in Appendix B of the Phase III Summary Report (provided as Appendix M to this report).

Four samples were tested for grain size distribution for use in the Human Health Streamlined Risk Evaluation (HHSRE). These samples were TP-2 0-0.5 feet, TP-6 0.5-1.2 feet, TP-16 0.5-1.0 feet, and TP-18 0-0.5 feet and the results are provided in Appendix B of the Phase III Summary Report (provided as Appendix M to this report). The samples analyzed from a depth of 0 to 0.5 feet have the potential for dust inhalation. The locations were selected to provide spatial distribution across the Site. They were also selected to reflect the type of material that may be encountered. TP-2 was located in native alluvium at the northern end of the Site. TP-6 is located in the upgrader discharge material. TP-16 is located in a typical drainage. TP-18 is located in the TENORM at AUM 457. Although there were some differences in the relative amounts of percent sand and percent fines, all four samples were classified as fine sand. Interpretation of these results in the context of HHSRE exposure pathways is provided in Section 6.7.2.

5.0 ANALYSES AND RESULTS

5.1 Laboratory Data Validation

This section discusses the Level IV data validation results for soil samples collected during the Phase II and Phase III field investigations. Section 5.1.2 of the Quality Assurance Project Plan (QAPP) (provided as Appendix F to this report) specified that a Level IV data validation would be completed on 10% of the data packages and a Level II data validation would be completed on the remaining 90% of the sample results.

As described in Section 5 of the Project QAPP, the purpose of the data review, verification and validation is to document that the specified data requirements (sampling and analytical) defined in the Phase II Work Plan, FSP and QAPP were completed. The process of data verification assesses data completeness of recorded data and answers the question: "*Were the specified sampling or analysis procedure requirements followed to produce the data?*" Whereas, data validation is a process that evaluates compliance with method, procedure, and contract requirements, as well as quality objectives developed in measurement performance criteria. Data validation answers the question: "*Have all quality issues been resolved, and does the data meet the required quality measurement performance criteria?*" Data review, verification and validation procedures are provided in SOP-QA-100 (Exhibit C.1 of the QAPP).

Field records are reviewed to assess compliance with requirements specified in the Phase II Work Plan, the FSP and the QAPP, including assessment of these items:

- Samples correctly identified.
- Laboratory receipt of sample documented.
- Required field data collected and acceptable.
- Sample preservation requirements met.
- Required sampling procedures were followed.
- Required QC samples were collected.
- Custody records are complete.

5.1.1 *2017 Data Set*

The 2017 data set consisted of samples collected from the Background Study Areas (BSAs) during the Phase II investigation. The EA team collected 101 soil samples (92 originals and 9 field duplicates) and generated nine aqueous equipment rinsate blank (ERB) samples during the field investigations. All samples were shipped to ALS in Fort Collins, Colorado for analyses. One (original) soil sample container broke in shipment; consequently, analytical data are available from 100 soil samples (91 originals and 9 field duplicates). ALS reported the data from these samples in four work orders numbered:

- 1711413
- 1711418
- 1711420
- 1711421

The Level IV data packages are provided in Appendix G.1 of the Phase II Summary Report (provided as Appendix J to this report).

ERG conducted Level IV data validation (Ra-226 and gross alpha only) for one of these data packages (Work Order Number 1711413). This meets the requirement of 10% Level IV reporting and validation in the QAPP. Work Order Number 1711413 consists of data for the following samples.

- 24 background soil samples
- Two correlation samples
- Two field rinsate samples (water)
- Two duplicate soil samples

Validation of field generated radiometric data included assessing if minimum detectable activity criteria were met and identified any obvious spurious measurements. In addition, field logs and records were reviewed for any notes of unanticipated field conditions, anomalous equipment function, or anomalous readings.

ERG conducted Level II data validation on 100% of Ra-226 soil sample results and concluded that the data met the measurement quality objectives (MQOs) specified in the project QAPP.

The data validation summary memo for radionuclides is provided in Appendix G.1 of the Phase II Summary Report (provided as Appendix J to this report). Table 5-1 provides the data validation assessment of the relevant field data for background soil sampling. The validation of radiological analytical data identified that all field QA requirements were met with the exception of two items. First, the COC for one sample shipment was not signed though samples were confirmed to have remained in the custody of the sampler and a custody seal placed on the shipping container was intact upon receipt by the lab. Second, it was identified that all field rinsate samples were not preserved in the field and were preserved by lab but after the 5 days specified by the EPA Method 900.0. This preservation method was not identified in the QAPP or FSP. Lack of preservation was deemed unlikely to affect the analytical results since this is a low level field rinsate sample. Consequently, no data qualifiers were assigned for Work Order Number 1711413 as part of the ERG data validation.

As described in the QAPP (provided as Appendix F to this report), ALS provided Level IV data packages for the Phase II soil samples. EA completed a Level IV data validation on 11% of the non-radionuclide data packages by randomly selecting two or three samples from each of the four data packages (11 total samples). For these 11 samples a detailed review of field and laboratory documentation, standards used, maintenance performed, evaluation of field and laboratory QC sample results, and recalculation of the concentrations published by ALS was conducted. EA performed a Level II data validation on the remaining 89% of the data (89 samples), reviewing field and laboratory documentation, and evaluating field and laboratory QC sample results. Table 5-2 provides the data validation assessment of analytical laboratory non-radionuclide data for background soil sampling.

The EPA Quality Assurance Section completed a review of the data usability. The EPA Quality Assurance Section requested that the rinsate sample data be rejected and that *"all environmental data should be flagged as "J" accompanied by an explanatory comment that there is no usable rinsate quality control sample."* The EPA also indicated that "*there is presumptive and corroborating evidence that the environmental sample data were not biased due to cross-contamination."* The results of the EPA review were provided in a memorandum dated April 5, 2018, which is provided in Appendix G.3 of the Phase II Summary Report (provided as Appendix J to this report). Based on the EPA comments, the EA team has agreed to qualify the rinsate data with "R" (rejected) and flag the other laboratory results as "J" to identify that the rinsate data could not definitively confirm that absence of cross contamination between samples.

5.1.2 *2019 Data Set*

This section discusses the Level IV data validation results for soil samples collected during the Phase III investigation. The EA team submitted 59 soil samples (49 originals and 10 field duplicates), seven aqueous ERB, and one field blank of the water used to collect the ERB to ALS in Fort Collins, Colorado for analyses. Analytical data are available for all samples in Appendix E of the Phase III Summary Report (provided as Appendix M to this report). ALS reported the data from these samples in a single batch numbered 1812316. The Level IV data package for batch number 1812316 is provided in Appendix D.2 of the Phase III Summary Report (provided as Appendix M to this report).

Environmental Restoration Group, Inc. (ERG) conducted Level IV data validation (Ra-226 and gross alpha only) for the single laboratory data package (ALS batch no. 1812316) (ERG, 2019). This exceeds the requirement of 10% Level IV reporting and validation in the QAPP. Batch number 1812316 consists of data for the following samples.

- 5 background soil samples
- 44 correlation soil samples
- 10 field duplicate soil samples
- Seven field rinsate samples (water), plus one field blank of the rinsate water

Validation of field generated radiometric data included assessing whether minimum detectable activity criteria were met and identification of any obvious spurious measurements. In addition, field logs and records were reviewed for any notes of unanticipated field conditions, anomalous equipment function, or anomalous readings.

The data validation summary memo for radionuclides is provided in Appendix D.3 of the Phase III Summary Report. Table 5-3 provides the data validation assessment of the relevant field data. The validation of radiological analytical data identified that all field QA requirements were met except for three errors affecting COC forms:

1. Sample dates and times on laboratory COC forms were not completed. Individual sample IDs indicate the date of sampling.
2. Background soil samples were collected over two sample jars to ensure adequate sample volume. Instead of indicating on the COC that each jar was part of a set of two jars

representing a single sample location, the jars were listed individually on the COCs and logged in by the laboratory as separate samples. In effect, each jar was inadvertently requested to be independently analyzed by ALS, with the result that each background sample has its own field duplicate.

The intentional field duplicate collected at location D207 was also inadvertently duplicated, resulting in four independent analyses for location D207.

3. Eight of the twelve background samples (D207, D207-DUP, D208, D209, D209-DUP, D210, D210-DUP, D211) did not have their sample IDs properly recorded. These samples omitted the leading "D" required before the sample number specified by Section 3.3 of the Phase III Field Sampling Plan: Sample Identification and Labeling (provided as Appendix K to this report). The omitted "D" does not affect the sample traceability since other unique identifiers within the sample IDs differentiate samples from each other.

These errors do not compromise data integrity or the ability to properly identify and track samples. Field and laboratory results were determined to meet project data quality objectives (DQOs), as defined in the project QAPP, for radiological analyses. Consequently, no data qualifiers were assigned for batch number 1812316 as a result of ERG's data validation.

As described in the QAPP, ALS provided Level IV data packages for the Phase III soil samples. EA completed a Level IV data validation on 10% of the non-radionuclide data packages by randomly selecting six samples from the data package (EA, 2019a). For these six samples, EA conducted a detailed review of field and laboratory documentation, standards used, maintenance performed, evaluation of field and laboratory QC sample results, and recalculation of the concentrations published by ALS. EA performed a Level II data validation on the remaining soils data (5 samples), reviewing field and laboratory documentation, and evaluating field and laboratory QC sample results.

The data validation summary memo for metals is provided in Appendix D.1 of the Phase III Summary Report (provided as Appendix M to this report). Table 5-4 provides the data validation assessment of analytical laboratory data for soil sampling. Based on EA's review, all data were accepted as reported by ALS without further qualification except arsenic results from ALS "Prep Batch" IP190109-5. EA qualified the arsenic results for these 20 samples (Lab ID Nos. 1812316-26 through -48) as estimated ("J") based on low matrix spike/matrix spike duplicate results.

5.2 Correlation Study Results

5.2.1 *Surface Correlation Results*

5.2.1.1 Radium-226

ERG established correlations via regression modelling of Ra-226 soil concentrations, exposure rate, and static or scanning gamma count rate (as appropriate) via co-located measurements at 10 sites throughout the investigation area. The types of measurements and equipment used are described in Table 5-5. These correlation locations are depicted cartographically on Figure 3-1. One soil sample, collected from correlation location 10, was broken in-transit to the independent

laboratory. Because of the loss of sample integrity, location 10 was excluded from the analyses described below. In total, nine correlation points were used in the regression models.

Per the Phase II Work Plan (EA, 2017e), correlation soil samples were collected using a five-point composite sampling technique on November 6-7, 2017. Samples were analyzed for Ra-226 by ALS in Fort Collins, Colorado by EPA method 901.1m. The analytical results were correlated with average gamma-survey data collected within the composited area, consisting of a 10 by 10 meter grid centered on the correlation location, using simple linear regression. Table 5-6 presents the gamma survey summary statistics and associated Ra-226 soil data. The different number of gamma measurements within each correlation location is a function of four factors: 1) the required transect spacing at the correlation location; 2) the speed of scanning; 3) the presence or absence of objects and geological or topographical features which had to be navigated; and 4) the exact spatial geometry of the template used to compute the spatially-averaged gamma count rate. The distributions and coefficient of variation (CV) within each grid are appropriate and the central limit theorem says that the sample number (n) is adequate to characterize the mean in all cases. Figures 5-1 and 5-2 present the regression model results. The model showed good correlation between the two variables, with an adjusted coefficient of determination (r^2) value of 0.894, which exceeded the study DQO of $r^2 > 0.8$. Additional statistical analysis of the soil regression model is provided in Appendix C of the Phase II Summary Report (provided as Appendix J to this report). These correlations allow for an estimation of Ra-226 concentrations in soils. The correlation is valid for the same data collection method under the same conditions as the correlation locations. If the data collection method changes or the conditions of the site change, then the correlation may need to be updated to provide a reasonable estimate of the radium concentrations in soil.

5.2.1.2 High-Pressurized Ion Chamber and Gamma Count Rate Correlations

Two correlations were established using data from the high-pressurized ion chamber (HPIC):

- A correlation between exposure rate and static gamma count rate.
- A correlation between exposure rate and Ra-226 concentration in soil.

These correlations were established using simple linear regression using the software JMP 13.2.1 and verified in R (x64 v 3.4.3), Version *13.2.1*. SAS Institute Inc., Cary, NC, 1989-2007. Table 5-7 presents the data used to build the regression models, including: HPIC exposure rate, soil Ra-226 concentration, and static gamma count rate. Figures 5-3 and 5-4 depict the result of exposure rate regressed on static gamma count rate and exposure rate regressed on Ra-226 concentration in soil, respectively. Both regressions show good correlation and exceed the DQO of $r^2 > 0.8$. The exposure rate is shown on Figure 5-5

5.2.1.3 Metals Correlation

ERG also performed linear regression analysis to evaluate whether non-radiological constituents (arsenic, mercury, molybdenum, selenium, uranium, and vanadium) in the nine samples were significantly correlated with Ra-226 (a surrogate for gamma count rate). Separate models were run for each metal constituent in both the BSA and correlation sample pools presented in Section 5.3.

A significant correlation between a metal and gamma-survey data in the BSA data pool could indicate a stoichiometric relationship between mineral constituents in undisturbed soils. A significant correlation between a metal and mobile gamma data in the correlation pool could indicate a mine process that concentrated and/or co-located metals (e.g., the presence of a waste rock pile). However, none of the analyzed metals appears to be significantly correlated with the Ra-226 data (i.e., the observed adjusted r^2 values were less than the DQO of 0.8). Table 5-8 reports the adjusted r^2 values for each of the constituents, analyzed by pool.

During the Phase III evaluation the soil sampling results from the samples collected in areas with known mine-related material were used to more robustly investigate potential correlations between gamma-survey data and metal constituents as discussed in the following section.

5.2.2 *Subsurface Correlation Results*

The objective of this task was to develop mathematical correlations between:

1. Ra-226 concentrations in soil and net shielded static gamma count rate, as measured on a 1 liter Marinelli beaker of the same soil, and
2. Ra-226 concentrations and concentrations of arsenic, mercury, molybdenum, selenium, uranium, and vanadium in soil.

The test pit correlation soil and sediment samples represent a subset of the individual samples collected from the test pits. Test pit correlation populations vary in size due to the exclusion of U flagged metals data and also because one sample, from TP-14, did not have an associated representative ambient gamma measurement and therefore it was not possible to calculate a net shielded static gamma measurement to correlate with the concentration of Ra-226 in soil. If the analyte was analyzed for but not detected a "U" is entered. For samples, negative values are reported as non-detects.

Soil samples were analyzed by ALS for Ra-226, arsenic, mercury, molybdenum, selenium, uranium, and vanadium by the methods described in Table 4-6. The analytical results are provided in Table 5-9 for the correlation populations of each metal and Ra-226.

Analytical data were received from ALS on January 22, 2019. Statistical correlations were computed following the protocol described in the Phase III Field Sampling Plan (provided as Appendix K to this report). Ordinary least squares regression was used to relate soil concentrations of Ra-226 to net shielded gamma count rate and other constituents of interest (arsenic, mercury, molybdenum, selenium, uranium, and vanadium). The resulting analysis of variance (ANOVA) table is presented as Tables 5-10 through 5-18. The resulting mean regression is plotted on Figures 5-6 through 5-12. Assuming that a standard linear regression analysis describes the relationship between the dependent variable and the independent variable (Ra-226), for the purposes of this project an r^2 value of greater than or equal to 0.8 was required to define a meaningful site-specific correlation. This metric for r^2 is consistent with that described in the Phase II Work Plan (EA, 2017e). Error bars on the correlation plots represent the 95% confidence level uncertainty for radionuclides and ± 20% for metals. The grey banded region on the correlation plots represent the 95% prediction interval of the regression model.

The summary statistics for metals and radiological constituents in the correlation population is provided in Table 5-19. Table 5-20 reports the adjusted r^2 values for each of the constituents.

Correlations of Ra-226 to all metal PCOCs did not meet the project DQO of an adjusted r^2 value of 0.8 or greater. The summary ANOVA statistics for each of these correlations are contained in Tables 5-13 through 5-19. The correlations are displayed graphically on Figure 5-6, and Figure 5-8 through Figure 5-12. All correlations of Ra-226 to metals exclude U flagged data, if any. Because the presence or absence of Ra-226 in soil/sediment does not reliably and quantifiably correlate to the presence of metal PCOCs, it is not possible to use the concentration of Ra-226 in soil/sediment as a surrogate for the presence or absence of a metal PCOC.

The initial statistical model relating the concentration of Ra-226 in soil/sediment to static gamma count rate did not meet the project DQO for adjusted r^2 (adjusted $r^2 > 0.8$) for the complete correlation data set (n=43). The summary analysis of variance (ANOVA) statistics for the correlation are displayed in Table 5-10 and the correlation is displayed graphically on Figure 5-7.

However, as discussed in Section 5.0 of the Phase II Summary Report (provided as Appendix J to this report), two of the collected samples were identified as outliers and removed from the second correlation data set. Although a review of the laboratory analytical data and field notes from the associated samples did not identify any irregularities with sampling or analysis for these two samples, these two points were removed from the data set and a second Ra-226 to gamma regression model (n=41) was developed. These outlying data points were also excluded from all Ra-226 to metal regression analyses. The ANOVA table for the second Ra-226 to gamma regression (n=41) is presented in Table 5-12. The resulting mean regression is presented on Figure 5-13. Figure 5-13 presents a standard linear regression analysis that describes the relationship between the dependent variable and the independent variable (Ra-226) with the outliers removed.

With the outlying data points removed, the statistical model relating concentration of Ra-226 in soil/sediment to static gamma count rate met the project DQO for a correlation (adjusted r^2 value > 0.8). Based on this analysis, it is appropriate to use the correlation between soil/sediment concentration of Ra-226 and gamma radiation count rate to estimate the depth of TENORM exceeding the IL in the Project area, and to use this depth information to estimate removal volumes as an input to an alternatives analysis.

5.3 Background Study Area Pooling

To determine whether all of the BSA soil data could be pooled to calculate an upper tolerance limit (UTL) for background Ra-226 Site-wide, a non-parametric Dwass, Steel, Critchlow (DSC) test was performed on soil Ra-226 concentrations using the software R x64 v 3.5.0. The DSC test evaluates the distribution of each sub-population within the study against all other sub-population distributions to determine which, if any, sub-populations differ significantly (i.e., $p < 0.05$). The results of this test are given in Table 5-21. A statistical comparison of the pooling using the complete and censored data set is available in Appendix F of the Phase II Summary Report (provided as Appendix J to this report). The censored data set was developed at the request of EPA to remove data that the EPA felt was potentially impacted by mineralization or TENORM.

While useful, the pairwise test can only serve as a guide for pooling BSAs, as the transitive property is not inviolate when making statistical comparisons between populations. The following conclusions were drawn from the DSC test result:

1. The Little Colorado River BSA is significantly different from most other BSAs ($p < 0.05$). As presented on Figure 3-1, the LCR BSA is located in the active river channel and may contain sediments from upgradient sources. Thus, it is anticipated that the soil sediments in this location change with time as the river flows.

2. The Alluvial #1 and #2, Qter BRA, and Terrace #1 and #2 BSAs are not significantly different from each other.

3. The Drainage BSA #2 is different from most other BSAs.

Based on the pairwise results, it was evaluated whether it would be possible to pool the BSAs into three groups: Little Colorado River (LCR); Drainage #2; and Alluvial (consisting of Alluvial #1 and #2, Qter BRA, and Terrace #1 and #2 BSAs). A second pairwise DWS test was carried out on the pooled data, and each of these three pools is significantly different from the other ($p < 0.001$). Therefore, the three proposed pools of BSA data represent three distinct data sets and are proposed to be treated as three distinct background areas.

The area to which each BSA would apply was determined by examining similarities between the sites. Drainage #2 BSA was taken to be representative of the EPA-identified Site drainages and drainage areas bounding the LCR, as identified via the spatial extent of water-loving vegetative communities on Site orthophotos. The LCR pool was taken to be the active channel of the LCR, as depicted on Site orthophotos. The Alluvial pool was used for all remaining areas at the Site.

5.4 Delineation of Investigation Level

To delineate the investigation level (IL) for the horizontal gamma survey, it was necessary to determine which BSA would represent specific portions of the Site. The three pooled BSAs represent:

- Little Colorado River floodplain.
- Drainages upgradient of the LCR.
- Other locations/Alluvial.

The extent of the LCR floodplain was defined and discussed in Section 4.2. The background radiological conditions within this area are assumed to be similar to the LCR BSA. To define the spatial extent of drainage areas, the EPA-derived polygon depicting drainages was extended to connect the system to the LCR polygon. Background radiological conditions and the depositional environment within this area are similar to the Drainage BSA #2. The remainder of the Site was classified as "Other," represented by the Alluvial #1 and #2 BSAs, Terrace #1 and #2 BSAs, and EPA QTer BRA. The pooled background areas are presented on Figure 5-14. Figure 5-14 shows the pooled locations where each of the three background concentrations for Ra-226 have been applied. A statistical comparison of the pooling using the complete and censored data set is available in Appendix F of the Phase II Summary Report (provided as

Appendix J to this report). The censored data set was developed at the request of EPA to remove data that the EPA felt was potentially impacted by mineralization or TENORM.

The investigation level for the Site is defined as the 95% upper tolerance limit (UTL) for the gamma survey results for the relevant pooled BSA plus the gamma count rate corresponding to 1.24 pCi/g of Ra-226. The correlation relationship between Ra-226 established in Section 5.2 was used to convert 1.24 pCi/g of Ra-226 to a gamma count rate (3,612 cpm). Specifically, the equation on Figure 5-2, which represents the upper 95% prediction limit for Ra-226 at a given gamma count rate was used.

The lowest Ra-226 concentration in the correlation data set was 1.41 ± 0.24 pCi/g; 1.24 pCi/g (the concentration used to calculate the IL) is within the range of analytical uncertainty of the correlation study's lowest value. Furthermore, the use of the 95% upper prediction limit of the correlation to establish the IL provides a conservative estimate of the gamma count rate corresponding to 1.24 pCi/g. The uncertainty associated with extrapolating the linear regression beyond the lowest concentration of 1.41 ± 0.24 to 1.24 pCi/g is negligible when considering the analytical error of the laboratory and the conservative use of the 95% upper prediction limit.

The ILs for each of the pooled BSAs are presented in Table 5-22. These investigation levels, together with the gamma scanning data described in Section 4.4.2, were used to develop the binning shown on Figures 4-8 through 4-12.

5.5 TENORM Identification

The delineation of TENORM versus naturally occurring radioactive material (NORM) was completed for the gamma survey data points. The results of the TENORM delineation are shown on Figures 5-15 through 5-19. The delineation of TENORM was based upon a review of aerial photography, topographic features, which were delineated through field verification during the field reconnaissance discussed in Section 4.3 and Appendix A of the Phase II Summary Report (provided as Appendix J to this report). The use of aerial photography combined with knowledge of the Site allowed for the delineation of TENORM in areas of surface disturbance. Areas that were above the IL and topographically downgradient of an area that contained TENORM, which was above the IL, were considered to be TENORM (e.g., EPA-defined drainages). Data points above the IL that were not related to surface disturbance areas above the IL or connected by drainage pathways to areas that were above the IL were not considered TENORM.

5.6 Potential Material Migration

This section has been developed to evaluate possible past movement of material within and off the Site due rain events and erosion. A qualitative evaluation was completed using the gamma data and site topography to look for potential migration of material. This is discussed in more detail in the following section.

5.6.1 *Potential Material Migration from AUM 457*

Review of Figure 2-7 shows four areas with indication of the general flow direction of surface water near AUM 457. These four areas are discussed below in north to south order.

5.6.1.1 Northern Drainage

Review of the northern drainage shown on Figure 2-7 indicates that the drainage north of the pit area flows from the playa area towards the Little Colorado River. The drainage goes through a dam breach immediately west of the Section 9/Section 10 border. Potential flow into this area would be from the Playa to the west, the pit to the south and the dozer pushes from historic investigation from the north. Figure 4-9 shows that gamma surface surveys are at or below IL near the other mine related disturbance area. Figure 5-20 shows the gamma scan results for the defined drainages in cpm. The gamma scan results indicate that there are decreasing concentrations as the drainage approaches the LCR. Generally, readings above IL end approximately 300 feet west of the LCR. Additionally, soils excavated from Test Pit 2, shown on Figures 4-23 and 4-24, in the drainage have Ra-226 levels ranging from 2.69 to 2.82 pCi/g, which is below the IL of 2.95 pCi/g for drainages. This area does not show signs of surface erosion into the drainage area from the pit area as the surface of the pit area is exposed bedrock. Thus, this drainage has only marginal sources of mining wastes, and has no indication of historic transport of mine waste above IL levels into Section 10. Material migration is not considered likely for this drainage area.

5.6.1.2 Pond Area

The Pond Area is shown on Figure 2-7 and indicates that drainage from the pond berm is directed into the pond. Potential flow is from the crest of the berm into the impoundment. The surface surveys on Figure 4-9 show surface soils elevated to higher than 3 IL mainly in the southwest portion of the impoundment. Test Pits 4 and 6 were excavated from within the Pond Area as shown on Figures 4-23 and 4-24. These test pits had Ra-226 levels ranging from 1.61 to 5.92 pCi/g; some of the Ra-226 levels are above the IL value of 4.96 pCi/g. This drainage is self-contained and material migration is not considered possible for this drainage area.

5.6.1.3 Upgrader Area

The drainage to the east of the upgrader area is shown on Figure 2-7. This area drains from three paths around the upgrader to the east towards the LCR. The area exits to the west of LCR just north of the Wetland 3 area shown on Figure 2-7. Surface gamma surveys show areas greater than 3 IL in the drainages below the stockpile and upgrader, however, the southernmost finger of the drainage area has gamma surveys below 1 IL as shown on Figure 4-9. Figure 5-20 shows the gamma scan results for the defined drainages in counts per minute cpm. The gamma scan results indicate that there are decreasing concentrations as the drainage approaches the LCR. Test Pits 7, 8, and 9 were excavated in this drainage as shown on Figures 4-23 and 4-24. Test Pits 7 and 8 have Ra-226 levels above IL in the upper one foot. Test Pit 9 has Ra-226 levels above IL to a depth of 5 feet. Test Pit 9 encountered gravel at a depth of 5 feet that is likely not from the upgrader area, and native soils at a depth of 7 feet. There is evidence of erosion from the upgrader area down the drainage to the bank of the LCR in Section 10. The depth of the alluvial deposit from this erosion varies from 1 foot to 5 feet in the drainage. However, once the drainage intersects the LCR, the alluvium from the Site will be difficult to distinguish from the LCR alluvium being transported down the LCR from locations upgradient from the Site.

5.6.1.4 Bedrock Ridge West of AUM 457

Figure 2-7 shows drainage to the west off of the ridge west of the upgrader. Figure 4-9 shows this area is NORM material and is generally below IL. Direction of flow from this area would be

to the Playa. The Playa then drains north and reaches the Northern Drainage as discussed above. Flow is then out the drainage to the east towards the LCR. Gamma readings drop to IL or below approximately 300 feet west of the LCR. There has been no indication of historic transport of mine waste above IL into the LCR from this drainage area.

5.6.2 *Potential Material Migration from AUM 458*

Review of Figure 2-8 shows four areas with the general direction of surface water flow indicated. These four areas are discussed below.

5.6.2.1 Within AUM 458

AUM 458 is shown on Figure 2-8. The figure indicates that drainage from the inside of the pit is directed to the bottom of the pit. Potential flow is from the crest of the pit into the pit bottom. The no indication of surface water flow leaving the pit was observed during EA's site visits. As discussed in Section 9.1.2 the pit depth ranged from 18 to 30 feet. The surface gamma surveys in the AUM 458 area show that a majority of the surface material is more than three times higher than IL as shown on Figure 4-12. Test Pits 18, 19 and 20 were excavated inside the pit drainage area as shown on Figures 4-26 and 4-27. The soils in Test Pit 18 were below the Ra-226 background levels. The soils in Test Pit 19 were above the Ra-226 background levels, but these soils are limited to depth of approximately 1 foot due to shallow bedrock. The soils in Test Pit 20 were above the Ra-226 background levels. There is evidence of erosion from the pit walls and dozer pushes into the bottom of the pit. This drainage is self-contained and material migration is not considered likely for this drainage area.

5.6.2.2 Outside of AUM 458

The area outside of the pit capture area, but within AUM 458 boundary is shown on Figure 2-8. This area flows radially away from the pit capture area. The surface gamma surveys outside of the pit capture area are generally less than two times IL as shown on Figure 4-12. Test Pit 21 was excavated in this area at the location shown on Figures 4-26 and 4-27, and shows Ra-226 higher than IL. However, the gamma surveys in the NORM area outside of the AUM 458 boundary are less than IL as shown on Figures 4-11 and 4-12. There is limited evidence of erosion from the areas outside of the pit capture zone, however, the migration of this material is limited in nature, and gamma surveys of the NORM area surrounding the AUM 458 boundary show only a small area above IL west of AUM 458.Material farther to the north along the drainage is below IL as shown on Figure 4-12. Therefore, while there is evidence of erosion from the area, gamma survey data indicate the material has not historically migrated very far, and thus the potential for off-Site contamination is low.

5.6.2.3 Ridge South of AUM 458

There is an area of exploration along the ridge south of AUM 458 that is identified on Figure 2-8. The runoff from this ridge generally flows to either the west or east. The surface gamma surveys of the area are shown on Figure 4-12 and show the gamma levels to be 1 to 2 times the IL. Figure 5-20 shows the gamma scan results for the EPA identified drainage in cpm. The gamma scan results indicate that there are decreasing concentrations from the ridge line towards the east, towards Mays Wash. Test Pit 22 is located in this drainage basin as shown on Figures 4-26 and 4-27, and shows Ra-226 to range from 2.69 to 4.14 which exceeds the IL of 2.95 for drainage basins. There is limited evidence of erosion from this area to the west and east.

However, the gamma surveys in the NORM areas surrounding this feature are below the IL as shown on Figure 4-12. Therefore, while there is evidence of erosion from the area, gamma survey data indicate the material has not historically migrated very far, and thus the potential for off-Site contamination is low.

5.6.2.4 Drainage Southeast of AUM 458

There is a large drainage south and east of AUM 458. This drainage flows from the west in an easterly direction to the LCR. The drainage flows between AUM 458 and AUM 459 as shown on Figure 2-8. A finger of the drainage also originates north of AUM 458. The surface gamma surveys of the drainage southeast and downgradient of the AUM 458 area are shown on Figure 4-11 and show the gamma levels below IL. There is an area that is up to two times the IL in the finger drainage immediately north of AUM 458, however, downgradient of this area the gamma levels are below IL. Figure 5-20 shows the gamma scan results for the defined drainages in cpm. The gamma scan results indicate that there are decreasing concentrations as the drainage approaches the LCR. Test Pit 16 is in the drainage downgradient of AUM 458 and shown on Figures 4-26 and 4-27, and has Ra-226 readings of 1.2 and 1.23 which are below the IL value of 2.95 for drainages. Therefore, while there is evidence of erosion from the area, gamma survey data indicate the material has not historically migrated very far, and thus the potential for off-Site contamination is low.

5.6.3 *Potential Material Migration from AUM 459*

Review of Figure 2-8 shows two areas with the general direction of surface water flow indicated. As presented in 2.6.3, no visible mining-related disturbances related to AUM 459 in Section 9 other than the mine access road. Thus, TENORM on Section 9 likely migrated on site from Section 16. These two areas are discussed below.

5.6.3.1 Drainage North from AUM 459

There is a drainage that flows northeast from AUM 459 to the LCR. This drainage combines with two additional drainages before they enter the LCR floodplain as shown on Figure 2-8. The gamma survey data shown on Figure 4-11 indicate that the area where erosion from AUM 459 enters the drainage near the Section 9/Section 16 boundary is two to three times higher than the IL. These values drop to 1 to 2 times IL at the AUM 459 boundary, but remain at that elevated level until the drainage intersects the road approximately 650 feet north of the AUM 459 boundary. Further downgradient of the road the gamma surveys are less than the IL as shown on Figure 4-11, indicating that the material is not currently migrating into the LCR floodplain. Figure 5-20 shows the gamma scan results for the defined drainages in cpm. The gamma scan results indicate that there are decreasing concentrations as the drainage approaches the LCR. Test Pit 23 is in the AUM 459 boundary, just north of the Section 9/16 boundary, as shown on Figures 4-22 and 4-26. The Ra-226 values in Test Pit 23 range from 15.9 to 19.7 pCi/g and are above the IL value of 2.95 indicating that erosion of the material from AUM 459 is occurring into the drainage. There is evidence of erosion from AUM 459 into the drainage in Section 9. The material decreases in gamma values from the AUM 459 boundary downgradient to the road, but remains above the IL the entire distance. The alluvium below the road is below the IL until it enters the LCR floodplain. There is the potential for this elevated material to migrate into the LCR floodplain during larger storm events. However, once in the LCR it would be difficult to

distinguish from materials that were generated upgradient of the Site and transported down the LCR from locations upgradient from the Site.

5.6.3.2 Drainage Northwest of AUM 459

There is a large drainage northwest of AUM 459 as discussed in Section 5.6.2.4 above. This drainage flows from the west in an easterly direction to the LCR. The drainage flows between AUM-458 and AUM 459 as shown on Figure 2-8. The surface gamma surveys of the drainage southeast and downgradient of the AUM 458 area are shown on Figure 4-11 and show the gamma levels below IL. Figure 5-20 shows the gamma scan results for the defined drainages in cpm. The gamma scan results indicate that there are decreasing concentrations as the drainage approaches the LCR. Test Pit 16 is in the drainage, as shown on Figures 4-26 and 4-27, downgradient of AUM 458 and has Ra-226 readings of 1.2 and 1.23 which are below the IL value of 2.95 for drainages. This drainage merges with the Drainage North from AUM 459, as described in Section 5.6.3.1 above, at the LCR floodplain. While there is evidence of erosion from the area, gamma survey data indicate the material has not historically migrated very far, and thus the potential for off-site contamination is low.

5.6.3.3 Potential Migration Summary

Based on review of the Site topography, gamma survey and soil analytical results there is the potential for migration from the Site to the LCR from two areas: The Upgrader Area at AUM 457, and the Drainage North of AUM 459, based on current Site conditions.

6.0 HUMAN HEALTH STREAMLINED RISK EVALUATION

The Human Health Streamlined Risk Evaluation (HHSRE) provides information needed to establish the potential contaminants of concern (PCOCs), calculate risk to potential current and future receptors under current Site conditions. The HHSRE is used in conjunction with the Ecological Streamlined Risk Evaluation [EcoSRE] to *develop proposed action levels for* P*COCs that will be protective for users under the current and planned future use at the Site,* considering any recorded covenants restricting the use of the land. The assessment of potential human health risks for the non-radionuclide chemicals follow accepted EPA CERCLA requirements for conducting human health risk assessments (e.g., EPA, 1989). The potential human health non-radiological and radiological risks are calculated using the EPA on-line preliminary remediation goals (PRG) calculators adjusted to using site-specific exposure assumptions. Appendix Table F1-1 of the Phase III Summary Report (provided as Appendix M to this report) summarizes the variances from the Phase III Work Plan.

6.1 HHSRE Conceptual Site Model Development

The preliminary conceptual models for areas of potential human and ecological effects were developed in the Phase II Summary Report (provided as Appendix J to this report) for the AUMs and nearby areas. The PCOCs are derived from mining-related ore and waste rock that have been excavated from the near-surface uranium deposits and dispersed into the local environment. The principal potential Site-wide exposure pathways are ingestion and dermal contact with contaminated soils, inhalation of dust, and exposure to ionizing radiation. Separate risk calculations were prepared to reflect dry and wet conditions at the Site. The Dry Conditions Scenario is the more common environmental condition at the Site, allowing contact with soils at any location on the Site, including the dry Little Colorado River (LCR) channel bed. The Wet Conditions Scenario is relevant when water is present (flowing or stagnant) in the LCR channel, which precludes contact with the bed materials, as well as potential Site access from the east.

6.2 Evaluated Receptors

Given the streamlined nature of the HHSRE and the deed restriction that prohibits all future uses of the section with the exception of maintaining the access road, exhaustive analysis of all potential receptors and exposure pathways was not warranted. A copy of the deed restriction is provided in Appendix A of the Phase III Summary Report (provided as Appendix M to this report). The selection of receptors for the HHSRE was discussed in the Phase III Work Plan, and includes the following five receptor groups or activities:

- On-Site Adult Worker
- Long Term Adult Recreator (24 years of exposure)
- Child Recreator (2 years of exposure)
- Combined Long Term Adult and Child Recreator (26 years of exposure)

Receptors that were not directly evaluated in the HHSRE include residents (adult, adolescents and children), off-site workers, and off-site trespasser/ranchers (adult). The rationale for excluding these receptors was presented in the Phase III Work Plan, and is reproduced in Appendix Table F2-1 of the Phase III Summary Report (provided as Appendix M to this report).

Additional information regarding the exposure assumptions for each of these receptors is provided in Section 6.4.

6.3 Exposure Pathways and Scenarios

The evaluation of complete and incomplete exposure pathways for human receptors was provided in the Phase III Work Plan (provided as Appendix L to this report) as part of the Conceptual Site Models (CSMs). The CSMs were developed using Dry and Wet Condition Scenarios, defined below:

- *Dry Condition Scenario*: The exposure pathways evaluated for this scenario included external (e.g., gamma radiation), inhalation of dust, dermal contact, and ingestion of soils and the dry LCR channel bed sediments.
- *Wet Condition Scenario*: In the wet scenario is it assumed that no direct or indirect contact occurs for the evaluated receptors to the submerged LCR streambed sediments. External (e.g., gamma radiation), inhalation of dust, dermal contact, and ingestion of soils from the remainder of the Site were assessed for the evaluated receptors.

A separate risk analysis for exposure to radon gas was not evaluated because there are no intact buildings at the Site to accumulate the radon gas and any released radon would rapidly dissipate in outdoor air (ATSDR, 2012) [3]. Section 9, which is owned by Babbitt Ranches, has also been deed restricted so that no future use of the section is permitted including the construction of any buildings or other structures. A copy of the deed restriction is provided in Appendix A of the Phase III Summary Report (provided as Appendix M to this report).

Human health risk assessments typically also include evaluation of current and potential site activities to provide guidance for site risk management. Present-use scenarios reflect those that are occurring or can occur under current conditions. For this Site the only known activity is limited to occasional visits by Site Workers, although there is some evidence of unauthorized use of the property. Recreational use is commonly examined for U.S. Bureau of Land Management (BLM) sites and was also examined at this Site. It is anticipated that future uses at the Site will be similar to those under current conditions. Section 9 has also been deed restricted so that no future use of the section is permitted with the exception of maintaining the access road.

6.4 Receptors and Exposure Assumptions

The potential exposures that were evaluated in the HHSRE include direct (On-Site) exposure for (1) On-Site Workers; (2) Long Term Adult Recreator – 24 years; (4) Child Recreator – 2 years; and (5) Combined Child and Adult Recreator – 26 years. The exposure assumptions used in the HHSRE are consistent with those presented in the Phase III Work Plan and are provided by receptor group in Appendix F of the Phase III Summary Report (provided as Appendix M to this report). These were developed using standard sources, such as EPA's Exposure Factors Handbook (EPA, 2011), the more recent updates from EPA (EPA, 2014), and also Site-specific information on Babbitt worker activities. The derivation of the assumptions for Babbitt workers (that includes ranch laborers and cowboys located within 10 miles of Section 9) was provided in

[3] The radon isotopes Rn-218 and Rn-222 are included in the Ra-226 risk calculations since they are daughter products of Ra-226 decay.

the Phase III Work Plan (provided as Appendix L to this report) and supporting data are presented and additional data summaries are provided in Appendix F4-1b of the Phase III Summary Report (provided as Appendix M to this report). The Appendix F4-1b table summarizes information for key parameters (e.g., employment duration, cumulative duration of all visits over employment period) for (a) Babbitt workers that have actually visited the Site, and (b) Babbitt workers that have visited or could be assigned to visit the Site. The cumulative hours visited has a Reasonable Maximum Exposure (RME; equivalent to maximum in this case) value of 6 hours for either workers who have visited the Site or workers who have been assigned to visit the Site. Therefore, this value represents an upper end of the cumulative exposure over the entire employment period for all potential Site workers. No non-field Babbitt employees were included in the exposure assumption development since they have no potential to visit the Site. Babbitt Ranches does not actively ranch this land nor will they in the future due to the deed restrictions. Entry upon the property and any use of the property beyond that permitted in the deed restriction is prohibited and is trespass under Arizona law.

The Phase III Work Plan also discussed potential indirect (Off-Site) exposure, such as wind-borne migration of dust from the AUMs to the Little Colorado River floodplain for receptors in the Little Colorado River floodplain. These exposure pathways include inhalation exposures to wind-borne dusts released from the AUMs and incidental contact (ingestion) with wind-borne dusts that deposit in the floodplain area. The EPA PRG Calculator includes an estimate of exposure from suspended particulates. These results were used in lieu of using an air deposition model in the uncertainty assessment in Section 6.14.

EPA calculates potential risks for adult and child separately and also as an "aggregated individual" i.e., exposure assumptions for the child and adult are age-weighted and combined as a single receptor. The HHSRE presented results for the separate age groups and aggregate individual.

6.5 Identification of HHSRE PCOCs

The AOC identified the PCOCs, which are the same for both the HHSRE and the EcoSRE. These include the following: arsenic, mercury, molybdenum, selenium, uranium, vanadium, and Ra-226. Potential human health risks associated with mercury exposure were based on the toxicity of inorganic mercury, given that the evaluated exposure source is soils, and mercury is more likely to be in the inorganic form in soils.

6.6 Exposure Point Concentrations for HHSRE

The analytical data collected as part of the Phase II and III field programs were used to develop the Exposure Point Concentrations (EPCs). Prior to calculating the EPCs the samples with field duplicates were averaged. In those cases where one but not both of the sample-duplicate pairs was detected, the detected result was used as the sample result. This occurred with some of the selenium and molybdenum sample results.

EPCs that were used in the HHSRE represent the 95% upper confidence limit (95UCL) of the mean concentration of each PCOC. These 95UCLs were calculated using EPA-developed ProUCL software (version 5.1; Singh and Singh 2015; EPA, 2016d). This software provides

information on summary statistics (e.g., detection frequencies, ranges of detected results, means), assesses the distributions of the data (e.g., normal, lognormal, gamma), and calculates the Kaplan-Meier mean values (when the detection frequencies are less than 100%). The UCLs recommended by the software were used except in the cases where there was insufficient data to use the statistical analysis (such as from a small number of collected samples) or where the recommended UCL was greater than the maximum observed concentration. In these cases the maximum detected value was used.

Surface soil samples, defined as samples collected from a depth interval of 0 to 6 inches (or equivalently, 0 to 15 cm) were used for the EPC calculations since this depth interval has the greatest potential for exposure under current or future use conditions. For the evaluation of Ra-226, exposure could also occur (from radiological emissions) from greater depths. Most of the radium soils data (119 of 150 samples; 80%) were collected from a depth of 0 to 6 inches with 12 additional samples collected from a depth of 6 to 12 inches (the remaining 19 samples were collected from depth up to 4 feet from ground surface). The samples collected from 6 to 12 inches included two locations in AUM 457, four locations in AUM 458, one location in AUM 459, three test pit samples, one test pit drain sample, and one sample from the mine related disturbance area. Given that the 6 to 12 inch interval does not cover all areas of the Site, the effect on EPCs and calculated risks for radium exposure between the 0 to 6 inch and 0 to 12 inch interval will be evaluated in the uncertainty assessment.

HHSRE EPCs were calculated for the individual PCOCs using the following areas and scenarios:

- Area of Potential Effect (APE) With AUMs – wet and dry scenarios
- APE Less AUMs – wet and dry scenarios
- Outside of APE – same values for wet or dry scenarios
- Individual AUMs (AUM 457, 458, and 459) – same values for wet or dry scenarios for AUM 457; AUM 458 and 459 are dry scenario only
- LCR Channel Bed – dry scenario only

Results from the background areas were evaluated as part of the "Outside of APE" area and were not subtracted from the results of the soil samples collected from the APE. The assessment of the individual AUMs was added as an assessment area after submission and approval of the Phase III Work Plan with the concurrence of EPA and Babbitt Ranches. Separate EPCs were developed for the wet and dry scenarios for the APE with AUMs and APE less AUMs because in both cases the APE extends into the LCR channel bed. The Outside of APE and individual AUMs assessment represent both wet and dry scenarios because these are outside of the LCR channel bed.

The soil EPCs by PCOC and evaluated area are shown in Table 6-1. Additional summary information for each of the EPCs and the associated ProUCL outputs are provided in Appendix Table F3-2 and F3-3 of the Phase III Summary Report (provided as Appendix M to this report). Some of the recommended UCLs from ProUCL were not used because they exceeded the maximum detected concentration (e.g., molybdenum in AUM 458). In these cases, the maximum detected concentration was used as the UCL value. These are identified on Appendix Table F3-2 of the Phase III Summary Report (provided as Appendix M to this report).

A cross-tabulation of the soil Sample IDs and the evaluation area assignments is provided in Appendix Table F3-1 of the Phase III Summary Report (provided as Appendix M to this report).

EPCs for all of the PCOCs and all evaluated areas of the Site were developed with the exception of selenium, which was not detected in any of the samples collected from the LCR channel bed or AUM 459. The detection limit range in the samples from this area was 0.06 to 0.28 parts per million dry weight (ppm_{dw}) and 0.05 to 0.05 ppm_{dw}, respectively. This PCOC was excluded from the assessment of these evaluated areas of the Site.

Spatial averaging methods were not used for the HHSRE EPC development. This is discussed further in the uncertainty assessment.

6.7 Exposure Assessment

The exposure pathways that were evaluated for the three receptors listed in the Phase III Work Plan are ingestion of soils, dermal contact with soils (non-radiological PCOCs only), inhalation of dust, and exposure to ionizing radiation.

The objective of the exposure assessment is to estimate the type, magnitude, frequency, and duration of exposures for complete exposure pathways via intake equations. If the exposure occurs over time, the total exposure can be divided by the time period of interest to obtain an average exposure rate (e.g., mg/kg-day). The general equation for estimating a time-weighted average intake is:

$$\text{Intake} = \frac{\text{EPC} \times \text{IR} \times \text{EF} \times \text{ED} \times \text{Bf}}{\text{BW} \times \text{AT}}$$

where:

EPC	=	chemical concentration at the exposure point (e.g., milligrams per kilogram [mg/kg] sediment)
IR	=	intake rate (e.g., milligrams per day [mg/day])
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
Bf	=	bioavailability factor
BW	=	body weight of exposed individual (kg)
AT	=	averaging time (period over which exposure is averaged, usually measured in days)

Standard data sources were identified for this information (e.g., EPA, 2011) as well as other relevant literature sources and Site-specific and regionally relevant information. The exposure assumptions by receptor are provided in Appendix Table F4 series of the Phase III Summary Report (provided as Appendix M to this report).

The same exposure assumptions were used for the radiological and non-radiological risk calculations. Inputs for chemical risk assessments calculate exposures and risks on an equivalent

daily basis, for both the non-radiological and radiological EPA on-line calculators. The risks associated with radiological PCOC (i.e., Ra-226 and daughter products in secular equilibrium) were evaluated using the on-line EPA Radiological PRG Risk Calculator[4], while the risks for the non-radiological PCOCs are evaluated using the ORNL RAIS Contaminated Media (Risk) Calculator[5].

6.7.1 *Area Correction Factors*

The Area Correction Factor (ACF) is used by the EPA radiological PRG calculator to adjust for the finite size of the exposure area relative to the "infinite" source assumed when the dose coefficients were developed for Federal Guidance Reports 12 and 13 (Bellamy et al., 2014). The EPA radiological PRG calculator only allows for select areas to be used for Area Correction Factors. To achieve consistency between different aspects of the risk evaluations the area of each Site area was rounded to the closest of these pre-established values. This rounded area was then used for all other area entry inputs in the PRG calculators, both radiological and non-radiological risk calculations, for consistency. The actual and selected area for each Site area is displayed in Table 6-2. Some of the Site areas (e.g., APE with AUMs) are considerable larger than the largest selectable option in the PRG model range. To keep the risk evaluation within the EPA model bounds the largest selectable area was chosen, which was 1,000,000 m^2 or approximately 250 acres. Two sites, AUM 458 and LCR, were assigned ACFs of 100,000 m^2 or approximately 25 acres. These sites were later determined to be smaller than 25 acres but use of a larger Area Correction Factor in these cases was used for conservatism. ACFs are also used to calculate climatic conditions, volatilization factors, and wind driven particulate emission factors.

6.7.2 *Soil Grain Size Analyses*

As discussed in Section 4.4.2, four soil sample locations were analyzed for grain size distribution to assess the potential for wind entrainment. The sample-specific grain size and hydrometer analyses are provided in Appendix B of the Phase III Summary Report (provided as Appendix M to this report) and key parameters are summarized in Table 6-3. Given that all four samples, which represented different portions of the Site, had similar grain size characteristics (i.e., were all classified as fine sands) it is not anticipated that there would be significant differences across the Site for the potential for wind erosion.

6.8 Chemical Uptake Factors

For the HHSRE, the non-radiological PCOC-specific uptake factors from the Phase III Work Plan were used. These are shown in Appendix Table F4-3 of the Phase III Summary Report.

6.9 Toxicity Benchmarks

The toxicity benchmarks presented in the Phase III Work Plan were updated to reflect those from the EPA on-line risk tool used for the HHSRE. These are shown in Appendix Table F4-4a for non-radiological PCOCs and Appendix Table F4-4c of the Phase III Summary Report (provided as Appendix M to this report) for Ra-226 (and daughter products). Appendix Table F4-4b of the

[4] Accessed from this URL: https://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search
[5] Available from this URL: https://rais.ornl.gov/cgi-bin/prg/RISK_search?select=chem

Phase III Summary Report summarizes the target organ or systems, and the basis for the non-radiological non-cancer toxicity values.

6.10 Human Health Risk Characterization Approach

Risk characterization is the step in the risk assessment process that combines the results of the exposure assessment and the toxicity assessment for each PCOC to estimate the potential for cancer and non-cancer human health risks from chronic or subchronic exposure to that constituent. The methodology to estimate potential cumulative non-cancer and cancer risks from Site-related PCOCs is summarized below.

6.11 Non-Radiological Human Health Risks

For PCOCs that are evaluated for non-carcinogenic effects, the estimated average daily doses (ADDs) calculated for each exposure route considered for each PCOC are compared to reference doses (RfDs). The following formula is used to estimate the potential non-carcinogenic risk for each PCOC:

$$HQ = ADD \div RfD$$

where:

HQ = hazard quotient (unitless)
ADD = average daily dose of PCOC (mg/kg-day)
RfD = reference dose (mg/kg-day)

When the Hazard Quotient (HQ) for a given constituent and pathway does not exceed one, the RfD has not been exceeded, and the non-cancer health effects are below levels of regulatory concern as a result of potential exposure to that constituent via that pathway. The HQs for each constituent are summed to yield the Hazard Index (HI) for that pathway. A Total HI is then calculated for each exposure medium by summing the pathway-specific HI values. A Total HI value that does not exceed one is below levels of regulatory concern for the receptor's potential exposure to PCOCs in the environmental medium evaluated. The non-radiological PCOCs have overlapping target organs or effects (see Appendix Table F4-4b of the Phase III Summary Report). Consequently, the total HI represents the sum of the HI values across all of the non-radiological PCOCs rather than calculating target organ- or effect-specific HI values.

For the evaluation of the potential cancer risk associated with exposure to a PCOC, the toxicity factor (Cancer Slope Factor [CSF] for non-radiologicals) is multiplied by the lifetime average daily dose (LADD) calculated for that chemical through each exposure pathway, as shown in the equation below.

$$ILCR = CSF \times LADD$$

where:

ILCR = incremental lifetime cancer risk (no units)
CSF = cancer slope factor (1/[mg/kg-day])
LADD = calculated potential lifetime average daily dose of PCOC (mg/kg-day)

For potential excess lifetime cancer risks, EPA's acceptable risk range is between one-in-ten-thousand and one-in-a-million (1×10^{-4} to 1×10^{-6}). For exposures to multiple carcinogens, EPA (1989) has required that the upper bound cancer risks for all PCOCs in all exposure pathways for a given receptor be summed to derive a total cancer risk:

$$\text{Total cancer risk} = \sum \text{cancer risk for each PCOC}$$

As presented in Section 6.7, the non-radiological human health risks are evaluated using the ORNL RAIS Contaminated Media (Risk) Calculator. This calculator utilizes the methodology above to calculate both non-cancer and cancer risks. Risks were initially calculated for all receptors using the soil UCL EPC values. The risks based on the mean soil PCOC concentrations were calculated based on the ratios of the mean and UCL soil concentrations and the UCL risk results.

6.12 Radiological Human Health Risks

As presented in Section 6.7, the risks associated with radiological PCOCs were evaluated using the on-line EPA Radiological PRG Risk Calculator[6]. A similar equation to that for the ILCR is used but the CSF is replaced with the radionuclide-specific Slope Factor (SF). Potential radiological cancer risks were evaluated in the context of the upper end of EPA's acceptable risk range of 1×10^{-6} to 1×10^{-4}, and in addition were compared to the 12 mrem/year acceptable dose level per OSWER Directive No. 9200.4-18 (EPA 1997a; 3×10^{-4}), in accordance with the approved Phase III Work Plan (EA, 2019c). The standard output of this program includes a tabulation of the media- and radionuclide-specific EPC, dose calculations, and cancer risk results, as well as external dose calculations. The risks from exposure to Ra-226 assumed that Ra-226 was in secular equilibrium with its daughter products.

Risks were initially calculated for all receptors using the soil UCL EPC values. The risk based on the mean soil Ra-226 concentrations were calculated based on the ratios of the mean and UCL soil concentrations and the UCL risk results.

6.13 Receptor Specific Risks

This section summarizes the potential non-cancer and cancer risks by receptor. Each receptor summary includes results for all of the evaluated areas. The output from the on-line EPA calculators are provided in native Excel formats as part of the Appendix Table F5 series of the Phase III Summary Report.

6.13.1 *On-Site Worker*

The non-radiological cancer and non-cancer risk values for the individual PCOCs are shown in Table 6-4a and the HI values (sum of all HQ values) and sum of cancer risks are shown in Table 6-4b.

All of the cancer risks from exposure to arsenic were below 1×10^{-6}, the lower end of EPA's acceptable cancer risk range, indicating that the potential cancer risk from this non-radiological

[6] Accessed from this URL: https://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search

PCOC in soils from any area of the Site for this receptor was below the level of regulatory concern. All of the HQ values were below one for the non-radiological PCOCs, indicating that the potential risks from exposure to the PCOCs by this receptor group from any area of the Site were below the level of regulatory concern.

The Ra-226 Site-specific soil EPCs were used as inputs to the EPA online calculator and the risk results are also shown in Table 6-4a. All of the cancer risks from exposure to Ra-226 and its associated daughter products in soils were on the order of 1×10^{-8} or smaller based on the UCL EPC values for all of the evaluated portions of the Site. The calculated risks were at least two orders of magnitude lower than 1×10^{-6}, the lower end of EPA's acceptable cancer risk range, and at least four orders of magnitude lower than the 1×10^{-4} threshold from OSWER Directive No. 9200.4-18 (EPA 1997a). The Ra-226 risk values are well below the level of regulatory concern for this receptor group from the evaluated portions of the Site.

The HI values (sum of non-radiological PCOC HQ value) were less than one and the sum of the cancer risks (sum of arsenic and Ra-226 risks) were also less than 1×10^{-6} indicating potential risks across the PCOCs for this receptor for all of the evaluated areas were below the levels of regulatory concern.

Outputs for both the radiological and non-radiological EPA calculators for this scenario are located in Appendix Table F5 series of the Phase III Summary Report (provided as Appendix M to this report).

6.13.2 *Long Term Adult Recreator – 24 years of Exposure*

This scenario is based on an exposure duration of 24 years by a Long Term Adult Recreator. Use of the Site by a Long Term Adult Recreator is prohibited under the deed restriction and is a trespass under Arizona law. The non-radiological cancer and non-cancer risk values for the individual PCOCs are shown in Table 6-5a and the HI values (sum of all HQ values) and sum of cancer risks are shown in Table 6-5b.

All of the cancer risks from exposure to arsenic were below 1×10^{-6}, the lower end of EPA's acceptable cancer risk range, indicating that the potential cancer risk from this non-radiological PCOC in soils from any area of the Site for this receptor was below the level of regulatory concern. All of the HQ values were below one for the non-radiological PCOCs, indicating that the potential risk from exposure to the PCOCs by this receptor from any area of the Site were below the level of regulatory concern.

The Ra-226 Site-specific soil EPCs were used as inputs to the EPA online calculator and the risk results are also shown in Table 6-5a. All of the cancer risks from exposure to Ra-226 (and its associated daughter products) in soils are below or within the EPA acceptable cancer risk range (i.e., less than or equal to 1×10^{-4} risk), and were below the OSWER risk value, across the evaluated areas, except for AUM 458 (UCL and mean EPC). The calculated risk (2×10^{-4}) using the average Ra-226 soil level in AUM 458 (22.1 pCi/g) was less than the 12 mrem/year acceptable dose level per OSWER Directive No. 9200.4-18 (EPA 1997a; 3×10^{-4}). The calculated risk (6×10^{-4}) using the UCL Ra-226 soil level in AUM 458 (73.9 pCi/g) was greater than the 12 mrem/year acceptable dose level.

Table 6-5b summarizes the HI values (non-radiological PCOCs only) and the sum of the cancer risks (arsenic plus Ra-226). The HI values were less than one for all of the evaluated portions of the Site. The sum of the cancer risks were the same (after rounding) to the Ra-226 only results because the arsenic cancer risks are two to three orders of magnitude lower than the Ra-226 risks and did not significantly change the combined cancer risks.

Outputs for both the radiological and non-radiological EPA calculators for this scenario are provided in Appendix Table F5 series of the Phase III Summary Report (provided as Appendix M to this report).

6.13.3 *Child Recreator – 2 years of Exposure*

This scenario assesses potential risks to a child that accompanies an adult recreator. Use of the Site by a Child Recreator is likewise prohibited by the deed restriction and is a trespass under Arizona law. The non-radiological cancer and non-cancer risk values for the individual PCOCs are shown in Table 6-6a and the HI values (sum of all HQ values) and sum of cancer risks are shown in Table 6-6b.

All of the cancer risks from exposure to arsenic were below 1 x 10^{-6}, the lower end of EPA's acceptable cancer risk range, and therefore the potential cancer risk from this non-radiological PCOC in soils from any area of the Site for this receptor was below the level of regulatory concern. All of the HQ values were below one for the non-radiological PCOCs, indicating that the potential risk from exposure to the PCOCs by this receptor from any area of the Site were below the level of regulatory concern.

The Ra-226 Site-specific soil EPCs were used as inputs to the EPA online calculator and the risk results are also shown in Table 6-6a. All of the cancer risks from exposure to Ra-226 (and its associated daughter products) in soils were below or within EPA's acceptable risk range (i.e., less than or equal to $1x10^{-4}$ risk), and were below the OSWER risk value based on the average or UCL EPC values for all of the evaluated portions of the Site. Therefore, the Ra-226 risk values were below the level of regulatory concern for this receptor from the evaluated portions of the Site.

Table 6-6b summarizes the HI values (sum of non-radiological PCOC HQ values) and the sum of the cancer risks (arsenic plus Ra-226). The HI values were less than one for all of the evaluated portions of the Site. The HI values (non-radiological PCOCs only) were less than one and the sum of the cancer risks (non-radiological and radiological) were below or within the acceptable risk range of regulatory concern for this receptor group from the evaluated portions of the Site.

Outputs for both the radiological and non-radiological EPA calculators for this scenario are provided in Appendix Table F5 series of the Phase III Summary Report (provided as Appendix M to this report).

6.13.4 *Combined Child and Long Term Adult Recreator – 26 Years of Exposure*

In this scenario an individual was assumed to have spent 2 years visiting the Site as a child and 24 years as an adult, each of which is prohibited under the deed restriction and in violation of Arizona law. The non-radiological cancer and non-cancer risk values for the individual PCOCs are shown in Table 6-7a and the HI values (sum of all HQ values) and sum of cancer risks are shown in Table 6-7b.

All of the cancer risks from exposure to arsenic were below 1 x 10^{-6}, the lower end of EPA's acceptable cancer risk range, and therefore the potential cancer risk from this non-radiological PCOC in soils from any area of the Site for this receptor was below the level of regulatory concern. All of the HQ values were below one for the non-radiological PCOCs, indicating that the potential risk from exposure to the PCOCs by this receptor from any area of the Site were below the level of regulatory concern.

The Ra-226 Site-specific soil EPCs were used as inputs to the EPA online calculator and the risk results are also shown in Table 6-8a. All of the cancer risks from exposure to Ra-226 (and its associated daughter products) in soils were below or within the EPA acceptable cancer risk range (i.e., less than or equal to $1x10^{-4}$ risk), and were below the OSWER risk value, for all of the evaluated portions of the Site, except AUM 458. The calculated risk ($2x10^{-4}$) using the average Ra-226 soil level in AUM 458 (22.1 pCi/g) was less than the 12 mrem/year acceptable dose level per OSWER Directive No. 9200.4-18 (EPA 1997a; $3x10^{-4}$). The calculated risk ($6x10^{-4}$) using the UCL Ra-226 soil level in AUM 458 (73.9 pCi/g) was greater than the 12 mrem/year acceptable dose level.

Table 6-8b summarizes the HI values (sum of non-radiological PCOC HQ values) and the sum of the cancer risks (arsenic plus Ra-226). The HI values were less than one for all of the evaluated portions of the Site. The sum of the cancer risks were the same (after rounding) to the Ra-226 only results because the arsenic cancer risks are two to three orders of magnitude lower than the Ra-226 risks and did not significantly change the combined cancer risks.

Outputs for both the radiological and non-radiological EPA calculators for this scenario are provided in Appendix Table F5 series of the Phase III Summary Report (provided as Appendix M to this report).

6.14 HHSRE Uncertainty Analysis Approach

The section discusses the HHSRE risk characterization and will also include a discussion of the quantitative and qualitative uncertainty of the HHSRE risk characterization.

6.14.1 *Representativeness of sampling*

The adequacy of the sampling strategies to characterize site conditions is a potential source of uncertainty. The Phase II and III sampling program was biased towards the assessment of Site features within and outside of the APE. Consequently, the PCOC soil concentrations would be biased high and represent an upper end estimate of a Site-wide average or UCL soil concentration. This is a reasonable approach in conducting a streamlined assessment to minimize the potential for missing potential areas that may cause potential risks.

6.14.2 *Receptor selection and representativeness*

Assessment of all potential human health receptors is not warranted for an HHSRE, which focuses on receptors that are more likely to be exposed to Site media. Although camping and related recreational activities are prohibited under the deed restriction, trespass under Arizona law and unlikely to occur at the Site, adult and child recreators were used to represent potentially highly conservative exposures by non-worker receptors that may visit the Site. Thus, although a receptor such as a trespasser was not explicitly evaluated, the long term recreator has an exposure profile that would yield more conservative risks than in these other receptors. An adult recreator with one year of exposure of transient recreational use at the site was evaluated and presented in Section 6.14.2.1. This was assumed to be comparable to a site trespasser.

The HHSRE also conservatively assumed that all of the exposures would occur at specific areas (e.g., the recreator would always camp at AUM 458). This is unlikely to occur on any portion of the Site due to lack of attractive features but would yield a highly conservative estimate of the potential risks.

6.14.2.1 Uncertainty Assessment - Short Term Adult Recreator (1 year of Exposure)

This scenario is based on an exposure duration of 1 year, reflective of a transient recreational use of the Site. Use of the Site by a Short Term Adult Recreator is prohibited by the deed restriction and is a trespass under Arizona law. The non-radiological cancer and non-cancer risk values for the individual PCOCs are shown in Table 6-8a and the HI values (sum of all HQ values) and sum of cancer risks are shown in Table 6-8b.

All of the cancer risks from exposure to arsenic were below 1 x 10^{-6}, the lower end of EPA's acceptable cancer risk range, and therefore the potential cancer risk from this non-radiological PCOC in soils from any area of the Site for this receptor was below the level of regulatory concern. All of the HQ values were below one for the non-radiological PCOCs, indicating that the potential risk from exposure to the PCOCs by this receptor from any area of the Site were below the level of regulatory concern.

The Ra-226 Site-specific soil EPCs were used as inputs to the EPA online calculator and the risk results are also shown in Table 6-8a. All of the cancer risks from exposure to Ra-226 (and associated daughter products) in soils were below or within the EPA acceptable risk range (i.e., less than or equal to $1x10^{-4}$ risk), and were below the OSWER risk value based on the average or UCL EPC values for all of the evaluated portions of the Site. Therefore, the Ra-226 risk values were below the level of regulatory concern for this receptor from the evaluated portions of the Site.

Table 6-8b summarizes the HI values (sum of non-radiological PCOC HQ values) and the sum of the cancer risks (arsenic plus Ra-226). The HI values were less than one for all of the evaluated portions of the Site. The sum of the cancer risks were below or within the acceptable risk range of regulatory concern for this receptor group from the evaluated portions of the Site.

Outputs for both the radiological and non-radiological EPA calculators for this scenario are provided in Appendix Table F5 series of the Phase III Summary Report (provided as Appendix M to this report).

6.14.3 *Comparison of Average and UCL Concentrations as EPCs and Effects on Calculated Risks*

The risk summary tables show the risks calculated using both the mean and UCL values, which provides bounds for the potential risks. The mean values provide a lower bound of the potential risks while the UCL represents an upper bound of the potential mean values. For a given receptor, the calculated risks are proportional to the EPC values. The risks calculating using either the mean or UCL values were below or within EPA acceptable risk limits for all PCOCs, all evaluated areas, and all evaluated receptors, except for Ra-226 in soils at the individual AUMs. As an example, using the combined adult and child recreator (Table 6-8a), for AUM 457 the average Ra-226 cancer risk was within EPA's acceptable risk range while the UCL cancer risks were at the upper end of EPA's acceptable risk range. For AUM 458, potential cancer risks using either the average or the UCL were greater than EPA's acceptable risk range. For AUM 459, where the average and UCL EPCs were the same (only a single sample was collected) the potential cancer risks were at the upper end of EPA's acceptable risk range.

6.14.4 *Spatial Averaging*

The potential to assess risks using the Site-wide spatial average was included as a possible method for consideration for EPC development in the Phase III Work Plan. Such an approach is useful for the assessment of larger sites, particularly when there is the potential for contact with media randomly across the Site. The HHSRE was structured to evaluate specific exposure areas (although it is assumed that contact with media is random within each of these areas). Spatial averaging methods typically yield more representative area-wide exposure estimates which are often lower than those calculated using conventional unweighted EPC methods. Therefore, use of the latter would yield upper bound estimates of the risks.

6.14.5 *Area Correction Factors*

As discussed in Section 6.7.1, the Area Correction Factors are used to adjust for the finite size of the exposure area relative to the "infinite" source assumed for radiological risk assessments. An ACF of 25 acres was assigned to two of the evaluated areas – AUM 458 and LCR channel area – although both are smaller than this area (Table 6-2). The areas of AUM 458 and LCR Channel are 14.4 and 14.5 acres, respectability. Using a smaller ACF results in a slight reduction (less than 5%) of the calculated risks (due to reduction in external dosing). For example, the calculated risks for a site worker at AUM 458 using the UCL EPCs would reduce from 2.8×10^{-9} to 2.7×10^{-9} when the ACF is adjusted from 25 acres to 14.4 acres (there would be no difference with rounded to one significant digit). The larger ACF was retained for conservatism.

6.14.6 *Off-Site Transport of Site Soils in Air*

An assessment of off-site transport of Site soils in air was included in the Phase III Work Plan. RESRAD-Offsite was originally intended to be used to predict the off-site media concentrations. However, the PRG calculator includes an estimate exposure related to particulate emissions into

the overlying air and inhalation of these suspended solids. Such exposures would be the largest in the evaluated areas and would dissipate (resulting in lower potential risks) the further one moves from the evaluated area. Inhalation exposures were a very minor component of the Site risks. For example, Table 6-9 compares the ingestion, dermal contact (for the non-radionuclide PCOCs), inhalation risks, or external exposures (for Ra-226) to the total risks at AUM 458 for all of the PCOCs. This AUM was selected because it had some of the higher PCOC UCL values. Results shown are for the adult recreator and 24 years of exposure. When inhalation is not the sole exposure route (as was the case for mercury) it contributes well below 0.04% to the total risk. Given that this pathway represents a *de minimis* at the evaluated area it is unlikely to represent a major exposure pathway if any soils migrate off-site.

Review of the EPCs (Table 6-1) further suggests there is not a large amount of off-site transport of soils from the Site. The LCR channel samples have some of the lowest PCOC concentrations relative to other evaluated areas of the Site.

6.14.7 *Assessment of Effects of Ra-226 Soils Collected from Depth*

Surface soils (defined as samples collected from a depth of 0 to 6 inches) were used for the risk characterization. However, radiological emissions from Ra-226 from soils collected from a depth of one foot also represent a potential source of exposure. Most of the radium soils data (119 of 150 samples; 80%) were collected from a depth of 0 to 6 inches with 12 additional samples collected from a depth of 6 to 12 inches. This portion of the uncertainty assessment compares the effects on EPCs and calculated risks to adult recreators from Ra-226 exposures for the 0 to 6 inch and 0 to 12 inch depth intervals.

The EPCs and calculated cancer risks for a long term adult recreator (e.g., 14 days per year for 24 years) for each of the evaluated areas is provided in Table 6-10. Additional summary information for the 0 to 12 inch Ra-226 EPCs is provided in Appendix Table F7-1a of the Phase III Summary Report (provided as Appendix M to this report). Table F7-1b lists the additional soil samples from the 6 to 12 inch depth interval that were depth averaged with their corresponding surface soil depth. The supporting ProUCL calculations for the 0 to 12 inch depth interval are provided in Appendix Table F7-2 of the Phase III Summary Report (provided as Appendix M to this report). A brief summary of the changes in the Ra-226 EPC concentrations and risks to the adult recreator by the addition of the 6-12 inch depth samples is discussed below:

- APE Area with AUMs (Dry Scenario): Seven samples from 6-12 inch depth were averaged with the corresponding 0-6 inch depth sample from this location, plus there were two additional samples (Drain-TP2 and MRD-TP1) which were not collected from the 0-6 inch depth. This increased the number of results from 62 to 65 from this area. The addition of these samples increased the mean (from 5.18 to 6.19 pCi/g) and the 95UCL (from 10.9 to 13.4 pCi/g). This resulted in a slight increase in the calculated risk based on the average EPC, but this was still within EPA's acceptable risk range. The calculated risk based on the UCL EPC also increased and was at the upper end of EPA's acceptable risk range (after rounding).
- APE Area with AUMs (Wet Scenario): Seven samples from 6-12 inch depth were averaged with the corresponding 0-6 inch depth sample from this location, plus there

were two additional samples (Drain-TP2 and MRD-TP1) which were not collected from the 0-6 inch depth. This increased the number of results from 50 to 55 from this area. The addition of these samples increased the mean (from 6.21 to 7.31 pCi/g) and the 95UCL (from 13.2 to 15.7 pCi/g). This resulted in a slight increase in the calculated risk based on the average EPC, but this was still within EPA's acceptable risk range. The calculated risk based on the UCL EPC was unchanged (after rounding) and was at the upper end of but within EPA's acceptable risk range.

- APE Area Less AUMs (Dry Scenario): One sample from 6-12 inch depth (TP-15) was averaged with the corresponding 0-6 inch depth sample from this location, plus there were two additional samples (Drain-TP2 and MRD-TP1) which were not collected from the 0-6 inch depth. This increased the number of results from 45 to 47 from this area. The addition of these samples increased the mean (from 2.48 to 3.10 pCi/g) and the 95UCL (from 2.93 to 6.00 pCi/g). Different UCL types were identified by ProUCL with the addition of the deeper samples. This resulted in a slight increase in the calculated risk based on the average EPC and approximate doubling based on the UCL EPC. However, all cancer risks were still within EPA's acceptable risk range.
- APE Area Less AUMs (Wet Scenario): One sample from 6-12 inch depth (TP-15) was averaged with the corresponding 0-6 inch depth sample from this location, plus there were two additional samples (Drain-TP2 and MRD-TP1) which were not collected from the 0-6 inch depth. This increased the number of results from 33 to 35 from this area. The addition of these samples increased the mean (from 3.05 to 3.85 pCi/g) and the 95UCL (from 3.56 to 7.59 pCi/g). Different UCL types were identified by ProUCL with the addition of the deeper samples. This resulted in a slight increase in the calculated risk based on the average EPC and approximate doubling based on the UCL EPC. However, all cancer risks were still within EPA's acceptable risk range.
- Outside of APE Area (Wet and Dry Scenarios): No change in EPCs or calculated risks since there were no additional samples from 6-12 inch depth. The cancer risks based on the average or UCL EPCs were all within EPA's acceptable risk range.
- APE 457 (Wet and Dry Scenarios): Two samples from 6-12 inch depth were averaged with the corresponding 0-6 inch depth sample from these locations. The addition of these samples decreased the mean (from 7.67 to 7.34 pCi/g) and decreased the 95UCL (from 15.8 to 14.9 pCi/g). The cancer risks based on the average or UCL EPCs were unchanged (after rounding).
- APE 458 (Dry Scenario Only): Three samples from 6-12 inch depth were averaged with the corresponding 0-6 inch depth sample from these locations, plus one additional sample (from TP18) which was not collected from the 0-6 inch depth. This increased the number of results from 5 to 6 from this area. The addition of this sample increased the mean (from 22.1 to 26.4 pCi/g) and the 95UCL (from 73.9 to 100 pCi/g). The 95UCL values for both the 0 to 6 inch and 0 to 12 inch depth intervals were the maximum detected value since in both cases the recommended 95UCL exceeded the maximum detected amount. The cancer risks based on the average EPCs were unchanged (after rounding), while the cancer risks based on the 95UCL EPCs increased (from 6×10^{-4} to 8×10^{-4}). Risks based on the average and UCL EPCs were both above the upper end of EPA's acceptable risk range.

- APE 459 (Dry Scenario Only): One sample from 6-12 inch depth was averaged with the corresponding 0 to 6 inch depth sample result (average of sample-duplicate pair) from this location. The mean and 95UCL EPCs slightly increased (from 15.0 to 17.3 pCi/g) by the addition of the deeper sample but there was no change in the calculated risks after rounding. Risks based on the average and UCL EPCs were within EPA's acceptable risk range.
- LCR Channel Area (Dry Scenario): No change in EPCs or calculated risks since there were no additional samples collected from 6-12 inch depth. The cancer risks based on the average or UCL EPCs were all within EPA's acceptable risk range.

In summary, there were increases in the soil mean and 95UCL EPCs for some of the evaluated areas, a decrease in the soil mean and 95UCL EPCs for one evaluated area, and no change in the soil mean and 95UCL EPCs for two areas, with the addition of the samples collected from 6 to 12 inches. The calculated risks were all less than or within EPA's acceptable risk range. Therefore, the assessment of potential risks based on the 0 to 6 inch depth interval soil results (a larger data set) is representative of the potential risk at the Site.

6.15 Summary of HHSRE Results

Tables 6-11a and 6-11b graphically summarize the individual PCOC HHSRE Non-Cancer (HQ) Results and the HHSRE Cancer Risk Results (respectively) for All Evaluated Receptors and Areas. For the non-cancer risk results (Table 6-11a) the following color coding was used:

- HQ values less than or equal to one = green.
- HQ values between one and 10 = yellow.
- HQ values greater than ten = red.

For the cancer risks (Table 6-11b) the following color coding was used:

- Cancer risks less than or equal to 1×10^{-4} = green.
- Cancer risks greater than 1×10^{-4} = red.

Risk results using both the UCL and mean EPC values are reported. The tables show all of the non-cancer and cancer risk results are coded green, indicating risks from the individual non-radiological PCOCs across the evaluated receptors and areas are below levels or within the acceptable risk range of regulatory concern.

Potential human health cancer risks from exposure to Ra-226 (and daughter products) in soils are below or within EPA's acceptable risk range for some of the receptors and the evaluated areas, except for the individual AUM 458. The potential risks from exposures to soils from the AUMs were below or within the acceptable risk range for site workers, and child recreators (2-year exposure duration). Potential cancer risks for exposure to AUM soils by long term adult recreators (24 years) and combined adult and child recreators (combined 26 years of exposure) varied depending on the whether the average or UCL soil values were used. Cancer risks for these two longer-term recreators were within EPA's acceptable risk range for AUM 457 when the average soil EPC was used but was above the upper limit of EPA's acceptable risk range for the UCL soil values in AUM 458. The calculated risks were slightly higher for the combined

adult and child recreators (combined 26 years of exposure) relative to the adult recreators (24 years).

The exposure pathways for human receptors included in this report were based on Babbitt Ranches, LLC and BLM current land usage. Current and future use of Babbitt land has been restricted and limited as set forth below:

- Section 9 is private property owned by Babbitt Ranches LLC that has been Deed Restricted.
- No active cattle operations or other active land use is permitted on Section 9, except as specified in the Deed Restriction discussed in Appendix A of the Phase III Summary Report (provided as Appendix M to this report).
- Entry onto Section 9 is a trespass under Arizona law and is also prohibited by the Deed Restriction.

The assumptions used for the human receptor exposure pathways represent our best judgment based on the information available at the time of preparation of this report. Navajo cultural values were not considered as part of the exposure pathways for human receptors in the above scenarios as there are not currently inputs reflective of these practices available for the PRG calculator. These inputs are being developed. Should additional information become available from the BLM, State, or other sources, prior to conclusion of this AOC, we will review and consider that information and modify our analyses accordingly. We provide this information regarding the development of these inputs as a reference point for future readers of this report.

7.0 ECOLOGICAL STREAMLINED RISK EVALUATION

The assessment of potential ecological risks for the non-radionuclide chemicals follows accepted EPA CERCLA requirements for conducting ecological risk assessments (e.g., EPA 1997b, 1998, 1999) and the potential ecological risks for the radionuclides were evaluated following the methodology from the Los Alamos National Laboratory (LANL, 2017a) ECORISK tool.

7.1 Ecological Setting

SWCA Environmental Consultants (SWCA) summarized the land use and ecological setting of the Site as part of their biological resources survey (SWCA, 2016). A copy of the SWCA (2016) report is provided in Appendix Attachment G.1 of the Phase III Summary Report (provided as Appendix M to this report). The key ecological setting relevant to the Ecological Streamlined Risk Evaluation (EcoSRE) is as follows.

- Climate at the Site is very dry, with temperatures below freezing in the winter (average minimum approximately 21°F) and very hot in the summer (average maximum temperature of approximately 97°F). For the available period of record (1962 to 1992) at nearby Cameron, Arizona[7] the average monthly precipitation ranges from 0.33 to 0.91 inch with an annual total of 5.7 inches. Average monthly total snowfall in the winter ranges from 0.1 to 0.7 inch, with an annual total of 1.9 inches.

- There are two named watercourses on or near the Site: an ephemeral reach of the Little Colorado River (LCR) along the eastern boundary of the Site and Mays Wash located on the south side of the Site. At the time of the biological survey (August 2016), there was no aquatic vegetation in the dry channel of the LCR (SWCA, 2016). There were a small number of shallow pools of standing water in the LCR that were remnants of recent thunderstorms. The shallow pools had no evidence of aquatic life. On average, the LCR channel is dry three months of the year (range: one to eight months). No standing pools were observed during the Phase II (completed September 12-17 and October 24-27, 2017) or Phase III (completed December 3-6, 2018) field work. The nearest perennial surface water with any hydrological connection to the Site is the lowest reach of the LCR, which begins approximately 58 miles downstream of AUM 457.

- At AUMs 457 and 458 Weston (2014) reported the presence of wetland habitats. Wetland scientists from SWCA visited the areas identified as wetlands in July and September 2014. Their evaluation was reported in SWCA (2016) and they did not observe wetland hydrology, hydric soils, obligate wetland vegetation, or other wetland organisms at either AUM. Furthermore, no wetland hydrology or obligate wetland vegetation was observed anywhere on the Site, although two facultative species (tamarisk and camelthorn) were observed at AUM 457, as well as throughout the LCR floodplain, in Mays Wash, and at several upland locations. The site conditions observed by SWCA were consistent with the observed conditions during the Phase II and III field work.

[7] Available from https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?azcame

As indicated in the SWCA (2016) report with regard to wetlands, *"SWCA's failure to find wetland indicators at either AUM 457 or AUM 458 raises the question of how the EPA evaluation and the SWCA evaluation of the same sites using the same protocol could come to opposite conclusions. We cannot answer that question definitively, but the EPA's evaluation in early August 2013 and SWCA's evaluation in late July and early September 2014 were conducted at roughly the same time of year but under vastly different hydrological conditions."*

- There are ephemeral drainage ways and some small "pocket" areas in the upland area where precipitation can accumulate. The latter are associated with some of the AUMs.

- There is vegetation in the riparian habitats along the LCR and Mays Wash, and within drainages and depressions in the upland areas. Vegetation in these areas is degraded by non-native, invasive species including tamarisk. The tamarisk has been defoliated by tamarisk leaf beetles. Most of the upland areas are sparsely vegetated by native (e.g., snakeweed, shadscale) and non-native species (e.g., camelthorn). There are only a few cottonwood trees in the area.

- AUMs 457 and 458 are located in the upland portion of the Site, although a small portion of AUM 457 is within the riparian buffer of the LCR. AUM 459 is located on Section 16 and material from AUM 459 has migrated onto Section 9. Generally, the substrates in these areas consist of poorly sorted fluvial gravel, pebbles, and cobbles partly consolidated in a matrix of mud and sand cemented with calcium and gypsum. There are competent outcrops scattered throughout the Site and near/within the AUMs, some of which have been disturbed from historical mining operations.

Representative photographs of the typical upland and riparian habitats of the Site are provided in Tables 2 and 3 of the SWCA (2016) report. A list of the known or expected terrestrial fauna that may use the Site is provided in Table 4 of SWCA (2016).

7.2 EcoSRE Conceptual Site Models

Two potential Ecological CSMs (EcoCSMs) were developed for the Site and presented in the Phase III Work Plan (provided as Appendix L to this report). One represents the more typical "dry" conditions when there is little to no water present in the LCR, and the other when flowing or standing water is present in the LCR.

The Dry Conditions Scenario is the more common environmental condition at the Site. Potential exposure areas include the upland areas (where the AUMs are located), the riparian buffer along the LCR dry channel, and the LCR dry channel.

The Wet Conditions Scenario is relevant when water is present (flowing or stagnant) in the LCR channel. The water flow of the LCR near the Site is ephemeral, as evidenced by the discharges

at USGS Gage Station 09402000 near Cameron, about 10 miles north of the Site (Figure 1-1)[8]. No surface water was available for collection during the Phase II or prior field investigations.

Potential representative receptors that were evaluated under "wet" LCR conditions are amphibians for direct contact (surface water), and insectivorous birds for indirect contact based on consumption of emergent insects.

7.3 Evaluated Receptors

Given the streamlined nature of the EcoSRE, exhaustive analysis of all potential receptors in a food chain is not warranted. Rather, the focus is on receptors that are representative of the lower and upper trophic level feeding guilds that may be present in the evaluated areas. The receptors proposed in the Phase III Work Plan were evaluated in the EcoSRE.

In the upland areas (e.g., the AUMs) under the Dry and Wet Condition Scenarios the following receptors were evaluated:

- Plants
- Insectivorous mammal: Desert shrew
- Insectivorous bird: Rock wren
- Herbivorous mammal: Deer mouse
- Insectivorous bird: American kestrel
- Carnivorous bird: Golden eagle

In the riparian areas (e.g., along the LCR) Dry and Wet Condition Scenarios the following receptors were evaluated:

- Plants
- Insectivorous mammal: Desert shrew
- Insectivorous bird: Rock wren
- Herbivorous mammal: Deer mouse
- Herbivorous bird: Mourning dove
- Omnivorous mammal: Coyote
- Carnivorous bird: Golden eagle

As noted in SWCA (2016), the habitats at the Site are not ideal for many of these receptors. For example, the golden eagle (which is on the Navajo Endangered Species List) may prey on small mammals at the Site but the sparse vegetation cover and defoliated tamarisk does not provide ideal habitat for small mammals.

The EcoSRE also semi-quantitatively evaluates the following two receptors that may use the LCR under the Wet Conditions Scenario:

- Amphibian: Spadefoot toad

[8] Data was summarized for the period of October 1, 2018 to October 1, 2019. This flow pattern during this period was consistent with the median flows for the last 70 years. Data was accessed from this link: https://waterdata.usgs.gov/nwis/uv?site_no=09402000

- Insectivorous bird: Rock wren

The rock wren is used to represent insectivorous birds that may prey on emergent aquatic insects when water is present in the LCR.

7.4 Identification of EcoSRE PCOCs

The AOC identified the PCOCs; these are the same for both the HHSRE and the EcoSRE. These include the following: arsenic, mercury, molybdenum, selenium, uranium, vanadium, and Ra-226. Risks associated with mercury exposure were based on the toxicity of methylmercury rather than on inorganic mercury. This is a conservative assumption that overestimates the potential risk to this PCOC associated with soil ingestion, given that mercury is more likely to be in the inorganic form in soils.

7.5 Exposure Point Concentrations for EcoSRE

The analytical data collected as part of the Phase II and III field programs were used to develop the exposure point concentrations (EPCs). As was done for the HHSRE, prior to calculating the EPCs the samples with field duplicates were averaged. In those cases where one but not both of the sample-duplicate pairs was detected, the detected result was used as the sample result. This occurred with some of the selenium and molybdenum sample results.

In an EcoSRE both the average and UCL media concentrations are used as EPCs to provide bounding estimates on the potential risks that can be useful for overall Site risk management. EPA's ProUCL software (version 5.1.02) was used to calculate the EPCs (EPA, 2016c).

The areas that were proposed for each evaluation in the Phase III work were the following:

- Site-wide (upland terrestrial only)
- Background study areas (BSAs) (river and upland)
- Riparian habitat along the LCR
- LCR dried sediment bed (based on prior reports)

In order to be consistent with the HHSRE, which evaluated exposures based on the APE, the EcoSRE assessment areas were adjusted to the following, incorporating the upland and riparian habitats at the Site:

- Upland Receptors – APE With AUMs
- Upland Receptors – APE Less AUMs
- Upland Receptors – Outside of APE
- Upland Receptors – Individual AUMs
- Riparian Receptors – Riparian Buffer Area within APE

The assessment of the individual AUMs was added to the EcoSRE after submission and approval of the Phase III Work Plan with the concurrence of EPA and Babbitt Ranches. There were no soil samples collected as part of the Phase II and III investigations from the riparian buffer areas outside of the APE. Therefore, this subarea was not evaluated in the EcoSRE.

The soil EPCs by PCOC and evaluated area are shown in Table 7-1. Additional summary information for each of the EPCs and the associated ProUCL outputs are provided in Appendix G, Tables G2-2 and G2-3 of the Phase III Summary Report (provided as Appendix M to this report), respectively. Some of the recommended UCLs from ProUCL were not used because they exceeded the maximum detected concentration (e.g., molybdenum in AUM 458). In these cases, the maximum detected concentration was used as the UCL value. These are identified on Appendix Table G2-2 of the Phase III Summary Report (provided as Appendix M to this report). A cross-tabulation of the soil Sample IDs and the evaluation area assignments is provided in Appendix Table G2-1 of the Phase III Summary Report (provided as Appendix M to this report).

EPCs for all of the PCOCs and all evaluated areas of the Site were developed with the exception of selenium, which was not detected in any of the samples collected from the Riparian Buffer Area within the APE or the Upland Individual AUM 459. The detection limit range in the samples from the Riparian Buffer within the APE ranged from 0.06 to 0.28 ppm_{dw} and the detection limit for the single sample from AUM 459 was 0.05 ppm_{dw}. This PCOC was excluded from the assessment of these evaluated areas of the Site.

Spatial averaging methods were not used for the EcoSRE EPC development. This is discussed further in the uncertainty assessment in Section 7.10.

7.6 Exposure Assessment

The primary exposure pathway assessed was indirect contact (i.e., consumption of forage or prey). Uptake of evaluated PCOCs into forage (e.g., plants) or prey (e.g., insects) is based on literature values. No Site-specific analytical data for forage or prey (e.g., insects) have been collected as part of the Phase II and III field investigation.

The general formula to calculate PCOC concentrations in the different biota that serve as prey or forage for higher trophic level organisms uses the following equation:

$$Conc_{biota} = Conc_{soil} \times BTF$$

Where the $Conc_{biota}$ is the biota concentration (on a dry or wet weight basis), the $Conc_{soil}$ is the soil (or sediment) concentration (typically on a dry weight basis), and the BTF is the biota transfer factor. BTFs represent the ratio of the chemical concentration in the biota and the chemical concentration in the soil or sediment. Two types of BTFs are typically reported in the literature:

- $BTF_{ww\text{-}dw}$: This form is the wet weight biota concentration divided by the dry weight soil or sediment concentration, and has units of kg_{dw}/kg_{ww}.
- $BTF_{dw\text{-}dw}$: This form is the dry weight biota concentration divided by the dry weight soil or sediment concentration, and has units of kg_{dw}/kg_{dw}.

Appendix Table G2-3 of the Phase III Summary Report (provided as Appendix M to this report) summarizes the BTF values that were used to calculate the plant and forage PCOC concentrations. The Phase III Summary Report BTF values were based on literature values, such

as the regressions developed by Sample et al. (1998) to estimate uptake from soils by small mammals across different feeding guilds (omnivore, herbivore, and insectivore). For the EcoSRE, these values were replaced with those from LANL (2017a). For the non-radionuclide metals the BTF unit for non-radionuclides is tissue mg/kg_{dw} per unit mg/kg_{dw} in soil, while the BTF unit for Ra-226 is tissue pCi/g_{ww} per pCi/g_{dw} in soil. The estimated Ra-226 tissue concentration is converted to equivalent dry weight basis using a moisture content of 68%.

The plant, soil invertebrate, and small mammal EPCs by PCOC and evaluated area are shown in Table 7-2. These were calculated from the mean and UCL soil values using the corresponding BTF values from Appendix Table G2-3 of the Phase III Summary Report (provided as Appendix M to this report).

7.6.1 *Exposure Calculations and Exposure Assumptions for Assessing Non-Radiological Risks*

The general equation used to estimate the non-radiological PCOC average daily dose (ADD) for these receptors is shown below:

$$\mathrm{ADD\,(mg/kg_{bw}\text{-}day)} = \frac{\left[(Cw \times IRw) + (Cs \times IRs) + \sum_{i}^{m}(Cd_i \times Fr_i \times IRd_i)\right] \times SUF \times AUF}{BW}$$

Where,

ADD	=	average daily dose (mg/kg_{bw}-day)
Cw	=	concentration of PCOC in unfiltered surface water (mg/L)
Cs	=	concentration of PCOC in soil/sediment (mg/kg_{dw})
Cd_i	=	concentration of PCOC in diet item (*i)* (mg/kg_{dw})
Fr_i	=	fraction of diet comprised of diet item (*i)* (unitless)
IRw	=	ingestion rate of surface water (liters per day [l/day])
IRs	=	ingestion rate of soil/sediment (kilograms (dry weight) per day [kg_{dw}/day])
IRd_i	=	ingestion rate of diet item (*i)* (dry weight) (kg_{dw}/day)
AUF	=	area use factor (unitless)
SUF	=	seasonal use factor (unitless)
BW	=	body weight (kilograms [kg]).

The exposure assumptions for assessing non-radiological risks are provided by receptors in Appendix Table G3-1 of the Phase III Summary Report (provided as Appendix M to this report). These were all based on standard data sources (e.g., EPA, 1993; Nagy, 1987; Sample and Suter, 1994)[9]. These assumptions were consistent with those from the Phase III Work Plan, with the addition of the assessment area-specific Area Use Factors (AUFs). The AUFs are based on the areal coverages of the assessed areas, the habitat information from SWCA (2016), and receptor

[9] The Nagy (1987) allometric equations, which were cited in the Wildlife Exposure Factors Handbook (EPA 1993), were preferred over the more recent Nagy (2001) publication since the latter did not include any information for the four receptors that used the Food Ingestion Rate allometric equations (mourning dove, rock wren, coyote, and golden eagle) or relevant surrogate species.

home range information from the published literature. The areal extents of each of the evaluated areas are shown in Appendix Table G3-2 of the Phase III Summary Report (provided as Appendix M to this report). These areas were generated using ArcGIS.

7.6.2 *Exposure Calculations and Exposure Assumptions for Assessing Radiological Risks*

For the assessment of potential radiological risks from Ra-226 exposure, the equation used to develop soil Ecological Screening Levels (ESLs) from LANL (2017a) was modified to include the receptor-specific AUF and SUF values. The general equation[10] is shown below.

$$ssESL = \frac{TRV}{((IR_{soil-dw}+(\sum_i^m(TF_{i-fw}xIR_{i-fw}))xTF_{blood}xR_txDCF_{int-fw}) + DCF_{ext}) * AUF * SUF)}$$

Where,

ssESL	=	site-specific ecological screening level for soil (pCi/g)
TRV	=	toxicity reference value, no-observed-adverse-effect level (NOAEL) and lowest-observed-adverse-effect level (LOAEL) based (rad/d)
IRsoil-dw	=	ingestion rate of soil (kilograms (dry weight) per day [kg_{dw}/day])
TF_i	=	transfer factor of diet item (*i)* (pCi/g [fresh weight] per pCi/g [dry soil])
IR_{i-fw}	=	ingestion rate of diet item (*i)* (g [fresh weight] per g body weight per day)
TF_{blood}	=	transfer factor to blood (unitless)
R_t	=	retention time (days)
DCF_{int-fw}	=	internal dose conversion factor (rad/d per pCi/g [fresh tissue])
DCF_{ext}	=	external dose conversion factor assuming either 180 or 360 degrees of exposure (rad/d per pCi/g [dry soil])
AUF	=	area use factor (unitless)
SUF	=	seasonal use factor (unitless)
BW	=	body weight (kilograms [kg]).

Ground-dwelling or foraging receptors (e.g., shrews) use DCF_{ext} based on 360 degrees of exposure while most avian receptors use DCF_{ext} based on 180 degrees of exposure.

The exposure assumptions for assessing radiological risks are provided by receptor in Appendix G Table G3-3 of the Phase III Summary Report (provided as Appendix M to this report). LANL (2017a) uses the beef transfer factor (TF_beef_fw) for all species exposed via the diet, including non-carnivorous species such as herbivorous birds, to calculate the transfer factor from blood to tissues (TF_blood). The latter is calculated as the product of the food ingestion

[10] Some of the variable names have been modified from the LANL (2017a) equation here for clarity. The original LANL variable names are provided in the input assumption table.

rate (I_food_fw), body weight, and TF_beef_fw. The associated User's Manual (LANL, 2017b) does not include an explanation of why a beef transfer term is used to calculate the blood transfer factor for herbivorous species. Therefore, Appendix G Table G3-3 of the Phase III Summary Report (provided as Appendix M to this report) includes the TF_beef_fw for all of the evaluated receptors exposed via the food chain.

7.7 Non-Radiological Toxicity Benchmarks

Non-radiological toxicity benchmarks were used to assess potential risks to plants, and avian and mammalian species. Soil screening levels were used to assess potential effects on vegetation. For the remaining receptors Toxicity Reference Values (TRVs) were used. Changes in the TRVs relative to the Phase III Work Plan are listed in Appendix G Table G1-1 of the Phase III Summary Report (provided as Appendix M to this report).

7.7.1 *Toxicity Benchmarks for the Assessment of Vegetation Effects*

Toxicity benchmarks for the assessment of potential impact on vegetation were not provided in the Phase III Work Plan but are shown in Table 7-3a. The soil Ecological Screening Levels (ESLs) for the evaluation of "Generic Plants" from the LANL (2017a) ECORISK Database were used for this assessment. Vegetation ESLs were available for all PCOCs except for molybdenum, which had no ESL value. M-EMS (2014) reviewed molybdenum toxicity to support the development of soil quality guidelines for this metal. Table C-3 from their report compiled total soil concentrations that represented EC_{10} and EC_{20}[11] toxicity benchmarks for growth-related endpoints (e.g., shoot length) in a variety of plants. The EC_{10} and EC_{20} values were considered comparable to NOAEL and LOAEL values (respectively) and are provided in Appendix G Table G6-2 of the Phase III Summary Report (provided as Appendix M to this report). The geometric means of the NOAEL and LOAEL soil concentrations were 15 and 73 mg/kg_{dw}, respectively. These values are within the range of the 10th and 90th percentiles for site-specific probable no effect concentration (PNEC) values in European agricultural soil of 10.7 and 168 mg/kg (Oorts et al., 2016).

7.7.2 *Toxicity Benchmarks for the Assessment of Effects on Mammalian and Avian Species*

Section 5.5.7 of the Phase III Work Plan presented the methodology to derive the toxicity benchmark for the ecological receptors. The principal data sources for the avian and mammalian TRVs are the Ecological Soil Screening Level (EcoSSL) documents and Sample et al. (1996); these were supplemented by the screening TRVs reported in LANL (2017a). The NOAEL and LOAEL values representing growth, reproduction, and survival effects endpoints were compiled from these studies and are presented in Appendix G Table G4 series and Table G5 series of the Phase III Summary Report (provided as Appendix M to this report) for the mammalian and avian receptors, respectively. The data were summarized two ways:

- The "Bounded TRV Summary" values were based on studies that reported both NOAEL and LOAEL values.

[11] EC_{10} and EC_{20} are the effective concentrations that reflect toxicity at 10 and 20%, respectively, of the control.

- The "All TRV Summary" values were calculated across all studies whether they represented bounded NOAEL and LOAEL values, or reported NOAEL or LOAEL values only.

As discussed in the Phase III Work Plan, those studies that report both NOAEL and LOAEL values (i.e., bounded NOAEL and LOAEL values) were preferred when deriving TRVs across multiple studies. The mammalian and avian TRVs are discussed below.

Mammalian TRVs

The mammalian TRVs for the non-radionuclide PCOCs are summarized in Table 7-3b and Appendix G Table G4-1 of the Phase III Summary Report (provided as Appendix M to this report). The following is a summary of the selected TRV_{NOAEL} and TRV_{LOAEL} values for the non-radiological PCOCs.

- *Arsenic*: The TRV_{NOAEL} and TRV_{LOAEL} values for arsenic were the geometric means of four bounded NOAEL and LOAEL results in mice from the EcoSSL document (EPA, 2005a) and were applied to all small mammal receptors. These were body weight scaled for the larger mammalian receptors.

- *Mercury (inorganic and methyl)*: The TRV_{NOAEL} values for mercury (inorganic and methyl) replaced the value from the Phase III Work Plan, and were applied to all mammals without body weight scaling. LANL (2017a) did not report a TRV_{LOAEL} value for mercury PCOCs.

- *Molybdenum*: The molybdenum TRV_{NOAEL} and TRV_{LOAEL} values for small mammals were updated based on data reported for rats in ATSDR (2017). These were body-weight scaled for the larger mammalian receptors. LANL (2017a) did not report mammalian TRVs for molybdenum.

- *Selenium*: The TRV_{NOAEL} and TRV_{LOAEL} values for selenium were the geometric means of 27 bounded NOAEL and LOAEL results in mice and hamsters from the EcoSSL document (EPA, 2007) and were applied to all small mammal receptors. These were body weight scaled for the larger mammalian receptors.

- *Uranium*: The TRV_{NOAEL} value for uranium from LANL (2017a) replaced the value from the Phase III Work Plan, and was applied to all mammals without body weight scaling. LANL (2017a) did not report TRV_{LOAEL} values for uranium PCOCs.

- *Vanadium*: The TRV_{NOAEL} and TRV_{LOAEL} values for vanadium were the geometric means of three bounded NOAEL and LOAEL results in mice from the EcoSSL document (EPA, 2005b) and were applied to all small mammal receptors. These were body weight scaled for the larger mammalian receptors.

The supporting calculations for the derivation of the TRV_{NOAEL} and TRV_{LOAEL} values are provided in the Appendix G Table G4 series of the Phase III Summary Report (provided as Appendix M to this report).

Avian TRVs

The avian TRVs for the non-radionuclide PCOCs are summarized in Table 7-3b and Appendix G Table G5-1 of the Phase III Summary Report (provided as Appendix M to this report). The following is a summary of the selected TRV_{NOAEL} and TRV_{LOAEL} values for the non-radiological PCOCs.

- *Arsenic*: TRVs were developed using unbounded results from the EcoSSL document (EPA, 2005a). The TRV_{NOAEL} was the geometric mean of eight NOAEL values and the TRV_{LOAEL} was the geometric mean five LOAEL values. There were no bounded NOAEL and LOAEL values available from this data source.

- *Mercury (inorganic)*: The TRV_{NOAEL} and TRV_{LOAEL} values for mercury (inorganic) were from Hill and Schaffner (1976), as cited by Sample et al. (1996).

- *Mercury (methyl)*: TRVs were developed using unbounded results from a literature review. The TRV_{NOAEL} was the geometric mean of three NOAEL values and the TRV_{LOAEL} was the geometric mean of six LOAEL values. Results are compiled in Appendix G Table G5-2b of the Phase III Summary Report (provided as Appendix M to this report).

- *Molybdenum*: TRVs for molybdenum were not available from the EPA/EcoSSL. The TRV_{NOAEL} used was from a study by Stafford et al (2016). A TRV_{LOAEL} could not be derived from this study.

- *Selenium*: The avian TRV_{NOAEL} and TRV_{LOAEL} values for selenium were the geometric means of 45 bounded NOAEL and LOAEL results in multiple avian species (American kestrel, black-crowned night-heron, chicken, duck, Japanese quail, and screech owl) from the EcoSSL document (EPA, 2007) and supplemented with the LANL (2017a) TRVs.

- *Uranium*: The uranium avian TRV_{NOAEL} and TRV_{LOAEL} values from LANL (2017a) were used as reported.

- *Vanadium*: The avian TRV_{NOAEL} and TRV_{LOAEL} values for vanadium were the geometric means of 58 bounded NOAEL and LOAEL results in multiple avian species (chicken, duck, screech owl, and Japanese quail) from the EcoSSL document (EPA, 2005b) and supplemented with the LANL (2017a) TRVs.

The supporting calculations are provided in the Appendix G Table G5-2 series of the Phase III Summary Report (provided as Appendix M to this report).

7.8 Radiological Benchmarks

Radiological benchmarks were used to assess potential risks to plants, and avian and mammalian species. Ra-226 is used as a surrogate to assess potential radiological effects of uranium since Ra-226 contributes approximately 97 percent of the total risk in the U-238 decay chain.

LANL (2017a) includes NOAEL and LOAEL based TRVs for all organisms of 0.1 and 1.0 rad/d, respectively. DOE (2002) has developed Biota Concentration Guides (BCGs) for assessing potential impacts to ecological receptors. These are radionuclide-specific, but are based on the following exposure thresholds (Yu, 2012): 1 rad/d for terrestrial plants and 0.1 rad/d for terrestrial animals. The latter is comparable to the TRV_{NOAEL} from LANL (2017a). The DOE dose criteria are for protection of the biota population rather than individuals.

The EcoSRE assessment of potential Ra-226 risks based on the LANL (2017a) method uses the NOAEL and LOAEL values of 0.1 and 1.0 rad/d, respectively.

7.9 Ecological Risk Characterization Approach

The hazard quotient approach was used to assess potential non-radiological and radiological risks. HQ was calculated using the following equation:

$$HQ = \frac{E}{TRV}$$

Where:

HQ	=	Hazard quotient
E	=	Estimated exposure
TRV	=	Toxicity reference value for the PCOC

Units used for exposure estimates and for the TRV may vary among lines of evidence, but must be the same for the numerator and denominator in the HQ equation. ESLs replace TRV in this equation when screening values are used for the comparisons.

An HQ greater than one indicates that exposure is greater than the toxicological benchmark, and the interpretation of this finding depends in part on the benchmark that is used. An HQ>1 that uses a LOAEL-based TRV is often interpreted as indicating a greater potential for risk than HQs that use a NOAEL-based TRV. Unless the NOAEL and LOAEL TRVs are accompanied by an exposure-response analysis, it is unclear what effect level corresponds with the HQ and, therefore, if an incremental change in HQ translates into a meaningful change in the likelihood or magnitude of effect.

For this EcoSRE, NOAEL- and LOAEL-based HQs (i.e., HQ_{NOAEL} and HQ_{LOAEL}) are calculated to provide a relative risk range to support the risk characterization. The magnitude of HQs does not necessarily indicate the potential for effects, since these are calculated from NOAEL- or LOAEL-based TRVs. The dose-response curves from chemical exposures are frequently not linear, which is not reflected in the NOAEL- or LOAEL-based TRVs. EPA has not identified a method of evaluating the magnitude of HQs relevant to the degree of risk to individuals or populations, and only recognizes whether an HQ is greater or less than "1." Also, risks that fall between the NOAEL and LOAEL may or may not be linked to adverse effects at the population or individual level, depending on chemical of interest and TRV that is used. Nonetheless, the relative magnitudes of the HQ values can guide the interpretation of the risk results, particularly when based on the LOAEL TRVs. Therefore, the following descriptors are used to interpret HQ results:

- If the HQ_{NOAEL} is less than or equal to one, no adverse ecological effect for the receptor population is expected to occur as a result of exposure to the PCOC.
- If the HQ_{NOAEL} is greater than one but the LOAEL HQ is less than or equal to one, then the potential for adverse ecological effect to a receptor population is considered low.
- If the HQ_{LOAEL} is greater than one then there is potential for population level effects.

The HQ results are presented by receptor and then an overall synopsis follows below.

7.9.1 *Plants*

The PCOC EPCs in soils, plant toxicity benchmarks, and the associated HQ values are shown in Table 7-4. The key results are summarized below:

- *Upland – APE with AUMs*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one, except for the molybdenum HQ_{NOAEL} value using the UCL which was above one. Although the molybdenum HQ value was greater than one the soil UCL value (36.7 mg/kg_{dw}) was within the range of NOAEL values used to derive the TRV_{NOAEL} (5 to 70 mg/kg_{dw}) and was also within the PNEC range (10.7 to 168 mg/kg_{dw}; Oorts et al., 2016).

  The vanadium HQ_{LOAEL} value using the UCL rounds to 1 but the calculated value was below one (0.95).

- *Upland – APE Less AUMs*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one, except for the vanadium HQ_{NOAEL} which was slightly above one (calculated value was 1.1) using the UCL soil concentration. The HQ_{LOAEL} values for both the average and UCL concentrations were less than one.

- *Upland – Outside of APE*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one.

- *Upland – AUM 457*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one, except for the molybdenum HQ_{NOAEL} value using the UCL soil concentration which was slightly above one (calculated value was 1.7). The HQ_{LOAEL} values for both the average and UCL concentrations were less than one.

- *Upland – AUM 458*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one for mercury, selenium and vanadium in soils. The non-radiological PCOCs values were greater than one for molybdenum and uranium, with the largest relative HQ values for molybdenum. The Ra-226 HQ_{LOAEL} value was slightly above one (actual value was 1.4) when the UCL soil concentration was evaluated. The HQ_{LOAEL} values were all below one, except for molybdenum using either the mean or UCL soil concentrations. These results indicate some potential for impacts to plants at AUM 458 due to molybdenum content of the soils.

- *Upland – AUM 459*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one except for the molybdenum HQ_{NOAEL} values which were greater than one. All of the HQ_{LOAEL} values were less than one.

- *Riparian – Riparian Buffer Area within APE*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one.

Based on these results it is not anticipated that there would be any impact to vegetation related to the PCOC concentrations in soils from any portion of the Site, except possibly from molybdenum in AUM 458. The geometric means of the soil NOAEL and LOAEL values for plant toxicity of molybdenum were used as the TRVs (Appendix G Table G6-2). Although the observed molybdenum mean and UCL soil concentrations (98.8 and 350 mg/kg_{dw}) were above the TRV_{LOAEL}, they are within the range of the LOAEL values (5 to 3,900 mg/kg_{dw}) indicating these exceedances of the TRVs may not reflect a measurable risk. SWCA (2016) reported that there is sparse vegetative cover (less than 10% spatial coverage) at this AUM and the densest vegetation was observed growing in a small depression at the bottom of the pit[12]. This is consistent with the conditions observed during the Phase II and III field work. The substrate at AUM 458 predominantly consists of waste rock piles and other mining debris which would limit the establishment of plants in this area.

7.9.2 *Herbivorous bird: Mourning dove*

The mourning dove is used as the representative species for herbivorous birds that may forage in the riparian areas of the Site. This receptor was not evaluated in the upland portions of the Site. The non-radiological EPCs in soils and diet (vegetation), calculated ADD, and the HQ values are shown in Table 7-5a. The HQ_{NOAEL} and HQ_{LOAEL} values were less than one for the riparian areas of the Site, using either the average or UCL soil concentrations. These results indicate any potential risk from exposure to the non-radiological PCOCs to this receptor group from the riparian areas of the Site is below levels of regulatory concern.

The Ra-226 soil EPCs were compared to the Site-specific ESL (ssESL) NOAEL and LOAEL values in Table 7-5b. The HQ_{NOAEL} and HQ_{LOAEL} values were less than one for the riparian areas of the Site, using either the average or UCL soil concentrations. These results indicate any potential risk from exposure to Ra-226 in soils to this receptor group from the riparian areas of the Site is below levels of regulatory concern.

7.9.3 *Herbivorous mammal: Deer mouse*

The deer mouse is used as the representative species for herbivorous mammal that may forage in the upland and riparian areas of the Site. The non-radiological EPCs in soils and diet (vegetation), calculated ADD, and the HQ values are shown in Table 7-6a. The key results are summarized below:

- *Upland – APE with AUMs*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one.

- *Upland – APE Less AUMs*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one.

- *Upland – Outside of APE*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the

[12] Photographs of AUM 458 are provided in Table 2 of SWCA (2016)

average or UCL concentrations were all below one.

- *Upland – AUM 457*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one.

- *Upland – AUM 458*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one for arsenic, mercury, selenium, uranium and vanadium. The molybdenum HQ_{NOAEL} value using either the average or UCL concentrations were above one. The molybdenum HQ_{LOAEL} value using the average concentration was below one, whereas the molybdenum HQ_{LOAEL} value using the UCL was greater than one.

- *Upland – AUM 459*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one except for the molybdenum HQ_{NOAEL} values which was slightly greater than one (actual value was 1.1). All of the HQ_{LOAEL} values were less than one.

- *Riparian – Riparian Buffer Area within APE*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one.

These results indicate any potential risk from exposure to the non-radiological PCOCs to this receptor group from the evaluated areas of the Site were below the regulatory level, except potentially from molybdenum in soils for this receptor group at AUM 458 only. Although the molybdenum HQ_{LOAEL} was greater than one, it may not be significant since the upper range of the LOAEL values was approximately 6.5 times larger than the geometric mean value used as the TRV (Appendix G Table G4-3c of the Phase III Summary Report).

The Ra-226 soil EPCs were compared to the ssESL NOAEL and LOAEL values in Table 7-6b. The HQ_{NOAEL} and HQ_{LOAEL} values were less than one for all evaluated areas, indicating any potential risk from exposure to Ra-226 in soils to this receptor group from any portion of the Site, including the individual AUMs, were below the regulatory level.

7.9.4 *Insectivorous bird: American kestrel*

The American kestrel is used as the representative species for insectivorous birds that may forage in the upland areas of the Site. This receptor was not evaluated in the riparian areas. The non-radiological EPCs in soils, calculated ADD, and the HQ values are shown in Table 7-7a. The HQ_{NOAEL} and HQ_{LOAEL} values were less than one for all evaluated areas of the Site, including the AUMs, using either the average or UCL soil concentrations. These results indicate any potential risk from exposure to the non-radiological PCOCs to this receptor group from the upland areas of the Site were below the regulatory level.

The Ra-226 soil EPCs were compared to the ssESL NOAEL and LOAEL values in Table 7-7b. The HQ_{NOAEL} and HQ_{LOAEL} values were less than one for all evaluated areas of the Site, including the AUMs, using either the average or UCL soil concentrations. These results indicate

any potential risk from exposure to the Ra-226 to this receptor group from any location at the Site were below the regulatory level.

7.9.5 *Insectivorous bird: Rock wren*

The rock wren is used as the representative species for insectivorous birds that may forage in the upland and riparian areas of the Site. The non-radiological EPCs in soils, calculated ADD, and the HQ values are shown in Table 7-8a. The non-radiological PCOC HQ_{NOAEL} and HQ_{LOAEL} values were less than one for all evaluated areas of the Site, including the AUMs, using either the average or UCL soil concentrations. These results indicate any potential risk from exposure to the non-radiological PCOCs to this receptor group from the evaluated areas of the Site were below the regulatory level.

The Ra-226 soil EPCs were compared to the ssESL NOAEL and LOAEL values in Table 7-8b. The HQ_{NOAEL} and HQ_{LOAEL} values were less than one for all evaluated areas, except for the HQ_{NOAEL} using the UCL soil concentration in AUM 458 which was slightly above one (actual value was 1.6). The Ra-226 HQ_{NOAEL} result is not considered significant since the HQ_{LOAEL} values were all below one for both the average and UCL soil concentrations.

7.9.6 *Insectivorous mammal: Desert shrew*

The desert shrew is used as the representative species for insectivorous mammal that may forage in the upland and riparian areas of the Site. The non-radiological EPCs in soils, plants, and invertebrates, calculated ADD, and the HQ values are shown in Table 7-9a. They key results are summarized below:

- *Upland – APE with AUMs*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one.

- *Upland – APE Less AUMs*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one.

- *Upland – Outside of APE*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one.

- *Upland – AUM 457*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one.

- *Upland – AUM 458*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one for arsenic, mercury, selenium, uranium and vanadium. The molybdenum HQ_{NOAEL} value using either the average or UCL concentrations were above one. The molybdenum HQ_{LOAEL} value using the average concentration was below one, whereas the molybdenum HQ_{LOAEL} value using the UCL was greater than one.

- *Upland – AUM 459*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one.

- *Riparian – Riparian Buffer Area within APE*: The HQ_{NOAEL} and HQ_{LOAEL} values based on either the average or UCL concentrations were all below one.

These results indicate any potential risk from exposure to non-radiological PCOCs in soils to this receptor group from any of the evaluated portions of the Site were below the regulatory level, except for molybdenum at AUM 458. Although the molybdenum HQ_{LOAEL} was greater than one, it may not be significant since the upper range of the LOAEL values was approximately 6.5 times larger than the geometric mean value used as the TRV (Appendix G Table G4-3c of the Phase III Summary Report).

The Ra-226 soil EPCs were compared to the ssESL NOAEL and LOAEL values in Table 7-9b. The HQ_{NOAEL} and HQ_{LOAEL} values were less than one for all evaluated areas, including the individual AUMs, indicating any potential risk from exposure to Ra-226 in soils to this receptor group from the evaluated any portion of the Site were below the regulatory level.

7.9.7 *Omnivorous mammal: Coyote*

The coyote is used as the representative species for omnivorous mammals that may forage in the riparian areas of the Site. This receptor was not evaluated in the upland portions of the Site. The non-radiological EPCs in soils and diet, calculated ADD, and the HQ values are shown in Table 7-10a. The HQ_{NOAEL} and HQ_{LOAEL} values were less than one for the evaluated areas of the Site, using either the average or UCL soil concentrations. These results indicate any potential risk from exposure to the non-radiological PCOCs to this receptor group from the Site is below the level of regulatory concern.

The Ra-226 soil EPCs were compared to the ssESL NOAEL and LOAEL values in Table 7-10b. The HQ_{NOAEL} and HQ_{LOAEL} values were less than one indicating any potential risk from exposure to Ra-226 in soils to this receptor group from the evaluated portion of the Site is below the level of regulatory concern.

7.9.8 *Carnivorous bird: Golden eagle*

The golden eagle is used as the representative species for carnivorous birds that may forage in the upland and riparian areas of the Site. The non-radiological EPCs in soils and diet, calculated ADD, and the HQ values are shown in Table 7-11a. The HQ_{NOAEL} and HQ_{LOAEL} values were less than one for all evaluated areas of the Site, including the AUMs, using either the average or UCL soil concentrations. These results indicate any potential risk from exposure to the non-radiological PCOCs to this receptor group from the Site is below the level of regulatory concern.

The Ra-226 soil EPCs were compared to the ssESL NOAEL and LOAEL values in Table 7-11b. The HQ_{NOAEL} and HQ_{LOAEL} values were less than one for all evaluated areas, including the AUMs, indicating any potential risk from exposure to Ra-226 in soils to this receptor group from any portion of the Site is below levels of regulatory concern.

7.9.9 *Assessment of Potential Receptor Risks in the LCR Under Wet Conditions*

The following receptors are evaluated semi-quantitatively in the LCR under the Wet Conditions Scenario:

- Amphibian: Spadefoot toad
- Insectivorous bird: Rock wren

Given the ephemeral nature of water in the LCR, it is likely that exposure to insectivorous birds to emergent aquatic insects will occur only when water is present in the LCR.

Amphibians

The spadefoot toad is the representative amphibian receptor that may use the LCR under wet conditions. This species buries itself in soft substrates and emerges to breed in the temporary ponds created by the heavy runoff, such as during the summer monsoons.

There were no surface water samples collected as part of the Phase II and III field programs therefore this assessment focuses on comparison to sediment benchmarks. Sediment benchmarks have not been developed to assess risks to amphibians or reptiles, except for some specific chemicals (e.g., total PCBs). However, sediment benchmarks for protection of aquatic organisms can be used as a surrogate for the assessment of burrowing amphibians, such as the spadefoot toad.

Table 7-12 compares the mean and UCL values from samples collected from the LCR channel – used as a surrogate for sediments from the LCR channel – to sediment benchmarks. There were multiple data sources for the sediment benchmarks The NOAEL and LOAEL values for arsenic, mercury, selenium, and uranium were from LANL (2017a) for aquatic community organisms and the values for Ra-226 were also from LANL (2017a) for all aquatic organisms. An alternate Ra-226 NOAEL benchmark from DOE (2002) was also used. LANL (2017a) did not have any NOAEL or LOAEL sediment criteria for molybdenum or vanadium. The molybdenum values were the Dutch Ministry target and intervention values for sediments reported in Friday (1998, 2005). The vanadium NOAEL value was from the NOAA Screening Quick Reference Tables (SQuiRT)[13] and represented background values for sediments. None of the observed mean or UCL values in sediments were greater than these benchmarks. Therefore, it is not anticipated that there would be any impacts to amphibians from PCOCs in the LCR channel under the Wet Scenario.

Insectivorous Birds

The rock wren is the representative insectivorous bird receptor that may use the LCR under wet conditions. Potential risks to the rock wren from exposure to solids in the upland and riparian areas of the Site were presented in Section 7.9.5. When water is present in the LCR, this species may also prey on emergent insects that were exposed to PCOCs present in the LCR channel substrate. Assuming the BTF-invertebrate values used for the Dry Conditions scenario would also apply to the potential uptake by emergent insects from the LCR channel area, a qualitative

[13] Available from https://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf

assessment of the potential rock wren risks under the wet scenario can be obtained by comparing the EPC from the channel area only to the EPCs from the remainder of the Site (Table 9-1 and Appendix G Table G2-2 of the Phase III Summary Report). The EPCs from the channel area are much lower than reported from the other portions of the Site. Given that the latter showed no HQ values above one, it is likely that there are not any potential risks to the rock wren (and other insectivorous birds) that may opportunistically feed on emergent insects under the LCR Wet Conditions and that potential risk is below the level of regulatory concern.

7.10 EcoSRE Uncertainty Analysis

This section discusses the EcoSRE risk characterization and includes a discussion of the quantitative and qualitative uncertainty of the EcoSRE risk characterization.

7.10.1 *Representativeness of sampling*

The Phase II and III sampling program was biased towards the assessment of Site features within and outside of the APE. Consequently, the soils PCOC concentrations would be biased high and represent upper end estimates of a Site-wide average or UCL soil concentration. This is reasonable for a streamlined assessment to minimize the potential for missing potential areas that may cause potential risks.

In their Site Inspection Report, Weston (2014) reported radionuclide and non-radionuclide results from five sediment samples collected along the edge of the LCR proximal to the AUMs (some background samples were also collected at other locations). The Phase II and III field programs collected additional soil samples from the dry channel of the LCR. During both field efforts no surface water was available for collection. USGS collects data on discharge and gage height for the LCR near Cameron, AZ (USGS Gage 09402000) but no chemical parameters. SWCA (2016) reported that the LCR surface water (when present) exhibits poor water quality due to high suspended solids and dissolved salts. Therefore, assessment from surface water could not be performed as part of the EcoSRE.

A literature review showed that there was no LCR biota data available near the Site. Andrews et al. (1995) collected fish and birds for metals and radionuclide analyses (but not Ra-226) from multiple stations in the Puerco River and Little Colorado River in August 1993. Their most downstream station (Station 7) was located approximately 30 km south of Cameron, upstream of the Site, but was designated an "observation site" rather than a "collection site" because it was "xeric and/or depauperate of species available for collection" at the time of their survey. Review of the USGS gage station data from August 1993 shows a spike of discharge near the end of August but virtually no flow prior to that period. The actual survey dates were not reported by the authors to verify whether they were present at the station during the no flow period.

7.10.2 *Receptor selection and representativeness*

As discussed earlier, evaluation of all potential receptors in a food chain is not warranted for an EcoSRE, which focuses on receptors that are representative of the lower and upper trophic level feeding guilds that may be present in the evaluated areas. The receptors proposed in the Phase III Work Plan were evaluated in the EcoSRE. The selected receptors represent a cross-section of feeding guilds across the habitats at the Site. The addition of the spadefoot toad for the LCR wet

scenario also reflects potential risks that may occur under intermittent wet conditions at the Site. The latter showed that risks are unlikely to this species because the LCR bed concentrations were all below screening benchmarks.

At the request of EPA, soil results from the evaluated areas were also compared to the screening benchmarks for earthworms, which were used as surrogate for soil invertebrates such as insects. ESLs were available for five PCOCs from LANL (2017a) and the molybdenum ESL (LOAEL only) was derived from information provided for springtails (*Folsomia candida*) and two earthworm species (*Eisenia andrei* and *Enchytraeus crypticus*) in M-EMS (2014; Appendix G Table G7-1 of the Phase III Summary Report). No invertebrate ESLs were available for vanadium which was not evaluated further. The available ESLs were compared to the mean and UCL soil values in Table 7-13. There were several HQ_{NOAEL} values greater than one calculated using the UCL soil concentrations, but most of the HQ_{LOAEL} values were less than one with exception of soils from AUM 458. Therefore, although soil invertebrates were not originally selected as a receptor group, their results are generally consistent with the conclusions from the plant assessment (Table 7-4).

7.10.3 *Conservatism from use of chemical uptake models to estimate prey and forage PCOC concentrations*

PCOC analytical results of forage (i.e., plants) and prey items were not available for the EcoSRE, which instead relied upon literature BTF values. These uptake factors do not account for soil characteristics or similar factors that may reduce the bioavailability of the PCOC. Use of BTF values is generally considered to be a conservative approach, and is appropriate for the streamlined process of an EcoSRE.

7.10.4 *Comparison of non-radiological and radiological risk results to those generated by the LANL EcoRisk model (LANL, 2017a)*

The LANL (2017a) methodology was used to assess potential risks from Ra-226 exposure. The default exposure assumptions were modified to reflect those of the evaluated receptors at the Site, and the receptor- and evaluation area-specific AUFs were additional variables in the calculations of the ssESLs. Table 7-14 compares the ssESLs to the ESLs from LANL (2017a) for similar species. With the exception of the coyote that has a large home range (and therefore small AUFs), the ssESLs were very similar to the ESLs from LANL (2017a). ESLs are not adjusted to AUFs. Therefore, development and use of ssESLs does not result in any undue uncertainty for the risk characterization.

7.10.5 *Development of non-radiological benchmarks (i.e., TRV)*

Several of the proposed non-radiological PCOC TRVs from the Phase III Work Plan were updated for the EcoSRE. This was predominantly due to the addition of the LANL (2017a) TRVs. The small mammal molybdenum TRV_{NOAEL} and TRV_{LOAEL} values were updated from the values presented in the Phase III Work Plan (which were based on a single mouse study)[14] following review of rat data from ATSDR (2017). These values were used as calculated for the

[14] The molybdenum TRV_{NOAEL} and TRV_{LOAEL} values from the Phase III Work Plan were 0.26 and 2.6 mg/kg-day, respectively.

assessment of potential molybdenum risks for all small mammals and were body weight scaled to assess potential risks to coyote. Body weight scaling of the rat TRV_{NOAEL} and TRV_{LOAEL} values could have been used to develop the small mammal TRVs. It is noteworthy that the body scaled TRV_{NOAEL} and TRV_{LOAEL} values are larger for the mouse (11 and 33 mg/kg-day, respectively) than those for the rat (Appendix G Table G4-2 of the Phase III Summary Report), indicating more conservatism in the risk characterization when the latter are used. Most of the molybdenum toxicological studies using mice have focused on inhalation exposures (ATSDR, 2017). ATSDR (2017) developed NOAEL of 5.3 and LOAEL of 11 mg/kg-day based on reproductive endpoint (abnormalities in mouse oocytes) from the study by Zhang et al (2013). These values are larger than those proposed in the Phase III Work Plan, but consistent with the TRV_{NOAEL} and TRV_{LOAEL} values developed based on rat data. Given these results use of the rat TRVs as a surrogate for all small mammals would not unduly misrepresent the potential toxicity of molybdenum to the evaluated small mammal receptors at the Site.

The non-radiological PCOC TRVs were based on a mixture of bounded and unbounded NOAEL and LOAEL results. This was PCOC specific and varied based on the availability of data. As discussed in the Phase III Work Plan, preference was made to use bounded values, although unbounded values were used in several cases (e.g., avian TRVs for arsenic and methylmercury). The avian arsenic TRVs can be used as an example when the unbounded NOAEL and LOAEL values were used. This was required in this case because there were no bounded NOAEL and LOAEL values available from EcoSSL (EPA 2005a) and LANL (2017a). The mammalian arsenic TRVs are an example where the geometric means of the bounded values were used rather than the unbounded values. There were four unbounded values but seven unbounded NOAELs and 13 bounded LOAELs, which yielded geometric mean values of 4.57 and 3.89 mg/kg-day, respectively. It is counterintuitive to use a LOAEL that is smaller than the NOAEL. Consequently, the bounded NOAEL and LOAEL values were used to assess potential arsenic risks to small mammals even though it was based on a smaller data set.

7.11 Summary of EcoSRE Results

Tables 7-15a and 7-15b graphically summarize the EcoSRE HQ_{NOAEL} and HQ_{LOAEL} results for the non-radiological PCOCs and radiological PCOC (respectively) across all receptors and evaluated areas. For both tables the following color coding was used:

- HQ values less than or equal to one = green.
- HQ values between one and 10 = yellow.
- HQ values greater than ten = red.

Risk results using both the mean and UCL EPC values are reported. Review of Table 7-15a shows the following:

- Most of the HQ values for plants were coded green, indicating the HQ values were below the regulatory limit. As discussed in Section 7.9.1, exceptions were molybdenum in several of the areas (APE with AUMs, AUM 457, AUM 458 and AUM 459), and vanadium in one evaluated area (APE outside of the AUMs). As discussed in Section 7.9.1, the molybdenum soil concentrations in AUM 458 were within the range of the LOAEL values indicating these exceedances of the TRVs may not reflect a measurable risk above the levels of regulatory concern. The vanadium HQ_{NOAEL} was only slightly

above one using the UCL soil concentration and is not considered to be significant given that the HQ_{LOAEL} values were both below the level of regulatory concern. Local substrate quality may be more important for the establishment of plants in this AUM than PCOC concentrations in the soil.

- Most of the HQ values for small mammals (deer mouse, desert shrew) were coded green, except for molybdenum in AUM 458 and 459. The molybdenum HQ_{NOAEL} results from deer mouse exposure to soils in AUM 459 are not considered significant since the HQ_{LOAEL} values were all below one. These results suggest some potential for risk above EPA's level of regulatory concern to molybdenum in soils for small mammals at AUM 458 only. Although as discussed in Sections 7.9.3 and 7.9.6 the molybdenum HQ_{LOAEL} results may not be significant since the upper range of the LOAEL values was approximately 6.5 times larger than the geometric mean value used as the TRV.

  HQ values for the large mammal (coyote) were all coded green, indicating the HQ values were below the level of regulatory concern from exposure to the assessed areas.

- Risks for all of the avian species, which includes the golden eagle, were coded green indicating any potential risk from any the non-radiological PCOCs across the Site were below the regulatory limit.

As shown in Table 7-15b, all of the Ra-226 HQ_{LOAEL} values were coded green, indicating any potential risks to the receptors across the evaluated areas to this radiological PCOC the HQ values were below the regulatory limit. The HQ_{NOAEL} values were also coded green for all receptors except for plants and rock wrens when using the UCL soil concentration for Ra-226 in AUM 458. Risks using the average Ra-226 soil concentration were coded green for plants and rock wrens.

Overall, most of the potential ecological risk above the level of regulatory concern is associated with exposure to soils in AUM 458 but this is restricted to plants and small mammals only. Larger mammals and all avian species do not have any calculated HQ values greater than one from exposure to Site soils and thus were below EPA's level of regulatory concern.

8.0 PROPOSED RISK BASED ACTION LEVEL

In accordance with the AOC (EPA, 2016a), the methodologies and assumptions used by the HHSRE (and the EcoSRE) were used to *"... calculate proposed action levels for* (P)*COCs that will be protective for users under the current and planned future use at the Site."* The more conservative (i.e., lower) of the PCOC-specific HHSRE or EcoSRE risk based action levels (rbALs) were used to calculate *"...the volumes* (sic) *of contaminates soil and sediment with concentrations above the screen levels and with concentrations above the proposed risk based action levels"* (EPA, 2016a). Development of Action Levels for future remediation were not part of the AOC or this RSE.

The HHSRE provides information needed to establish the potential contaminants of concern (PCOCs), and calculate risk to potential current and future receptors under current Site conditions, taking into consideration any recorded covenants restricting the use of the land. The HHSRE showed potential cancer and non-cancer risks for the non-radiological PCOCs were less than the levels of regulatory concern and hence acceptable to the EPA for the evaluated human receptors at the Site. Potential human health cancer risks from exposure to Ra-226 (and daughter products) were below or within the acceptable risk range for On-Site Workers, and Child Recreators (2-year exposure duration). Risks for longer term Adult Recreators (24 years) and Combined Adult and Child Recreators (combined 26 years of exposure) were below or within the acceptable EPA cancer risk range (i.e., range less than or equal to $1x10^{-6}$ to $1x10^{-4}$ risk), and were below the OSWER risk value (i.e., $3x10^{-4}$), for all areas of the Site except for AUM 458. The highest relative risks are calculated for exposures at AUM 458.

Given these results, the following approach was used to develop the rbALs for the Site:

- Acceptable soil concentrations at the three acceptable cancer risk levels (i.e., 1×10^{-6}, 1×10^{-5} and 1×10^{-4}) and a non-cancer risk level of one (i.e., HQ of one) were calculated for each PCOC using the input soil UCL value for AUM 458 (73.9 pCi/g) and the risk results for all the evaluated receptors. The AUM 458 area showed the largest risk relative to the other evaluated areas.

- The human-health based rbALs were then compared to the soil concentrations back calculated to HQ_{NOAEL} or HQ_{LOAEL} of one for the ecological receptors to determine whether they would be equally protective. Risks to the ecological receptors vary by their AUF values. Therefore, only the rock wren and desert shrew were used to assess the suitability of the human health rbAL values since they have AUF of one for all of the evaluated portions of the Site (except for AUM 459) and had the lowest ssESL values for Ra-226. AUM 459 was excluded because the AUFs were below one for both the desert shrew and rock wren in this area (see Appendix G Table G3-1 of the Phase III Summary Report).

- To estimate the soil concentrations that would achieve HQ_{NOAEL} or HQ_{LOAEL} values of one for the desert shrew and rock wren[15], regression lines were fit to the HQ and soil EPC values. Separate calculations were performed for the NOAEL and LOAEL based values due to the different TRVs used to calculate the HQ values. The regression lines were linear and all exhibited good fit (r^2 value > 0.93). The input values (mean and UCL soil values and HQ results for the two receptors) and the regression equation slope and intercept values are shown in Appendix F Table F6-2a and F6-2b of the Phase III Summary Report (provided as Appendix M to this report).

These rbAL values are based on the exposure assumptions used to assess the human and non-human receptors that may utilize the Site. The values are shown in Table 8-1a for Ra-226 and Table 8-1b for the non-radiological PCOCs. Supporting calculations are provided in Appendix F Table F6 series of the Phase III Summary Report (provided as Appendix M to this report). The proposed rbALs are discussed below:

- Ra-226: The Ra-226 human health rbAL values, which include daughter products (under secular equilibrium), were calculated for each of the following receptor groups and scenarios for the risk levels of 1×10^{-6} to 1×10^{-4} using the EPCs and risk results for AUM 458 (Table 8-1a).

  In the discussion below, the calculated Ra-226 rbALs were compared to the soil result for samples collected Outside of the APE, which can be considered regional background levels for Ra-226 in soils (Appendix F Table F3-2 in the Phase III Summary Report). The mean Ra-226 in these soils was 1.99 pCi/g with an overall range of 1.04 to 3.72 pCi/g. Ra-226 was detected in all of the samples collected Outside of the APE Area.

  - *On-Site Worker (Section 6.13.1)* – The potential rbALs ranged from 170 to 17,000 pCi/g across the risk levels of 1×10^{-6} to 1×10^{-4}. These were all greater than the Ra-226 values for soils Outside of the APE Area.

  - *Long Term Adult Recreator (14 days per year, 24 years of exposure; Section 6.13.2*): The potential rbALs ranged from 0.13 to 13 pCi/g across the risk levels of 1×10^{-6} to 1×10^{-4}. The rbAL values for risk levels of 1×10^{-6} and 1×10^{-5} are below the Ra-226 values for soils Outside of the APE Area.

  - *Child Recreator (14 days per year, 2 year of exposure; Section 6.13.4):* The potential rbALs ranged from 1.5 to 150 pCi/g across the risk levels of 1×10^{-6} to 1×10^{-4}. The rbAL value for the risk levels of 1×10^{-6} is below the values for soils Outside of the APE.

  - *Combined Child and Long Term Adult Recreator (14 days per year, 2 years as child and 24 years as adult; Section 6.13.5):* The potential rbALs ranged from

[15] Although the rock wren did not have any HQ values greater than one it was included in the development of the proposed rbALs to generate values for avian species.

0.12 to 12 pCi/g across the risk levels of 1 x 10^{-6} to 1 x 10^{-4}. The rbAL values for risk levels of 1 x 10^{-6} and 1 x 10^{-5} are below the values for soils Outside of the APE.

For the ecological receptors the NOAEL ssESL values ranged from 47 to 540 pCi/g and the LOAEL ssESL values ranged from 470 to 5,400 pCi/g. The geometric mean of the NOAEL values was 159 pCi/g. The latter value (rounded to 160 pCi/g) is the proposed ecological rbAL. As shown in Table 8-1a, for one of the evaluated human health receptors (On-Site Worker), the ecological rbAL would be more protective than the human health based rbAL for Ra-226.

The human health and ecological rbALs for non-radiological PCOCs are provided in Table 8-1b and are summarized below.

- Arsenic: The arsenic input soil UCL value for AUM 458 (27.7 mg/kg), the three acceptable cancer risk levels (i.e., 1 x 10^{-6}, 1 x 10^{-5} and 1 x 10^{-4}) and a non-cancer risk HQ value of one was used to develop the rbALs for this PCOC. The human health rbAL values ranged from 31 to 130,000 mg/kg for the risk levels of 1 x 10^{-6} to 1 x 10^{-4} and had a non-cancer risk level of 790 to 8,600 mg/kg (across all receptors except the Site Workers). For the ecological receptors the backcalculated NOAEL values ranged from 55 to 140 mg/kg and the LOAEL based value ranged from 120 to 360 mg/kg. The geometric mean of the NOAEL values was 88 mg/kg. The latter value (rounded to 90 mg/kg) is the proposed ecological rbAL. This would be protective of all evaluated human health receptors (potential cancer risk would be greater than 1x10^{-6}, but less than 1 x 10^{-5}) and is also below the LOAEL based risk values for the two ecological receptors.

  The proposed arsenic rbAL is greater than the mean (3.0 mg/kg) and range of results (1 to 5 mg/kg) for soils Outside of the APE (Appendix F Table F3-2 of the Phase III Summary Report), which is considered regional background. Arsenic was detected in all of the Outside of the APE soil samples.

- Mercury: The mercury input soil UCL value for AUM 458 (0.17 mg/kg) and an HQ value of one was used to develop the rbALs for this PCOC. The human health rbAL value was 450 mg/kg to 910 (across all receptors except the Site Workers). For the ecological receptors the backcalculated NOAEL values ranged from 0.25 to 1.3 mg/kg and the LOAEL based value was 1.1 mg/kg (a mercury LOAEL was not calculated for the desert shrew). The geometric mean of the NOAEL values was 0.57 mg/kg. The latter value (rounded to 0.6 mg/kg) is the proposed ecological rbAL. This would be protective of all evaluated human health receptors and still below the LOAEL based risk value for the avian ecological receptors.

  The proposed mercury rbAL is greater than the mean (0.0103 mg/kg) and range of results (0.00017 to 0.02 mg/kg) for soils Outside of the APE (Appendix F Table F3-2 of the Phase III Summary Report), which is considered regional background. Mercury was detected in all but one of these soil samples (detection limit of 0.0000595 mg/kg).

- Molybdenum: The molybdenum input soil UCL value for AUM 458 (350 mg/kg) and an HQ value of one was used to develop the rbALs for this PCOC. The human health rbAL value was 8,900 to 100,000 mg/kg (across all receptors except the Site Workers). For the ecological receptors the backcalculated NOAEL values ranged from 37 to 1,400 mg/kg and the single LOAEL based value was 120 mg/kg (a molybdenum LOAEL was not calculated for the rock wren). The geometric mean of the NOAEL values was 228 mg/kg, which is rounded to 230 mg/kg as the proposed ecological rbAL. This would be protective of all evaluated human health receptors.

  The proposed molybdenum rbAL is greater than the mean (0.254 mg/kg) and range of detections (0.0705 to 1.04 mg/kg) for soils Outside of the APE (Appendix F Table F3-2 of the Phase III Summary Report), which is considered regional background. Molybdenum was detected in 59% of these samples (24 of 41 samples) with a detection limit range of 0.17 to 0.19 mg/kg.

- Selenium: The selenium input soil UCL value for AUM 458 (0.518 mg/kg) and an HQ value of one was used to develop the rbALs for this PCOC. The human health rbAL value was 8,900 to 100,000 mg/kg (across all receptors except the Site Workers). For the ecological receptors the backcalculated NOAEL values ranged from 3.2 to 4.3 mg/kg and the LOAEL values ranged from 7.6 to 9.1 mg/kg. The geometric mean of the NOAEL values was 3.7 mg/kg, which is the proposed ecological rbAL. This would be protective of all evaluated human health receptors.

  The proposed selenium rbAL is greater than the mean (0.173 mg/kg) and range of detections (0.27 to 0.69 mg/kg) for soils Outside of the APE (Appendix F Table F3-2 of the Phase III Summary Report), which is considered regional background. Selenium was detected in 27% of these samples (11 of 41 samples) with a detection limit range of 0.0495 to 0.48 mg/kg.

- Uranium: The uranium input soil UCL value for AUM 458 (86.2 mg/kg) and an HQ value of one was used to develop the rbALs for this PCOC. The human health rbAL value was 360 to 4,200 mg/kg (across all receptors except the Site Workers). For the ecological receptors the backcalculated NOAEL values ranged from 450 to 7,500 mg/kg and the LOAEL value was 57,000 mg/kg. The geometric mean of the NOAEL values was 1,602 mg/kg. It is proposed that the human health value of 360 mg/kg be used as the rbAL. It will be protective of the evaluated ecological receptors.

  The proposed uranium rbAL is greater than the mean (2.54 mg/kg) and range of detections (0.930 to 9.55 mg/kg) for soils Outside of the APE (Appendix F Table F3-2 of the Phase III Summary Report), which is considered regional background. Uranium was detected in all of these samples.

- Vanadium: The vanadium input soil UCL value for AUM 458 (17.6 mg/kg) and an HQ value of one was used to develop the rbALs for this PCOC. The human health rbAL value was 9,000 to 100,000 mg/kg (across all receptors except the Site Workers). For the ecological receptors the backcalculated NOAEL values ranged from 77 to 11,020 mg/kg

and the LOAEL values ranged from 160 to 220 mg/kg. The geometric mean of the NOAEL values was 95 mg/kg, which is the proposed rbAL. This would be protective of all evaluated human health receptors.

The proposed vanadium rbAL is greater than the mean (43.2 mg/kg) and range of detections (13 to 88 mg/kg) for soils Outside of the APE (Appendix F Table F3-2 of the Phase III Summary Report), which is considered regional background. Vanadium was detected in all of these samples.

The rbALs are used to estimate waste volumes above these values in the next section.

9.0 REPOSITORY AND WASTE VOLUMES

9.1 CHARACTERIZATION OF PITS

Page 4 of Appendix A of the Administrative Settlement Agreement and Order on Consent (AOC) (EPA 2016a) states: "*Respondents shall measure and calculate volumes of mining pits to estimate their capacity to receive mining wastes*." EA used high resolution Light Detection and Ranging (LiDAR) topographic data collected at the Site in 2016 to develop volumes of the mine pits associated with AUM 457 and AUM 458. The LiDAR data was collected under the direction of Arizona licensed land surveyor (Maser, 2020). Conceptual layouts were prepared for various options for use of the AUM 457 and AUM 458 pits as mining waste repositories.

9.1.1 *AUM 457*

The LiDAR data for AUM 457 is presented on Figure 9-1. The pit at AUM 457 is approximately 6 feet deep on the east and west sides, 4 feet deep on the south side, and daylights into the drainage towards the north. The bottom of the pit slopes at approximately 2.5% from south to north. Two conceptual disposal layouts were prepared tying the top of a proposed cover into the side slopes on the west, south, and east sides of the pit and sloping to the north at 2%. The cover options were a layout with a 5H:1V slope on the north face tying into a 2% cover grade. The repository was assumed to have a 3 feet minimum cover thickness.

One option was prepared assuming a concave downward surface down the middle of the impoundment. This option was named the "Channel Cover Surface" and is presented on Figure 9-2. This option results in a total volume of 4,470 cubic yards (CY), with 3,130 CY required for the cover and 1,340 CY remaining for waste disposal.

A second option was prepared assuming a convex upward surface down the middle of the impoundment. This option was named the "Mound Cover Surface" and is presented on Figure 9-3. This option results in a total volume of 4,630 CY, with 3,070 CY required for the cover and 1,560 CY remaining for waste disposal.

9.1.2 *AUM 458*

The LiDAR data for AUM 458 is presented on Figure 9-4. The pit at AUM 458 is approximately 18 feet deep on the north and east sides, 30 feet deep on the south side and daylights into the drainage towards the west. The bottom of the pit is relatively flat. Three conceptual disposal layouts were prepared tying the top of a proposed cover into the side slopes on the north, east and south sides of the pit and sloping to the west at 2%. The cover options were prepared with a 2% cover grade. The repository was assumed to have a 3 feet minimum cover thickness.

One option was prepared assuming a concave downward surface down the middle of the impoundment. This option was named the "Channel Cover Surface" and is presented on Figure 9-5. This option results in a total volume of 2,770 CY, with 2,030 CY required for the cover and 740 CY remaining for waste disposal.

A second option was prepared assuming a convex upward surface down the middle of the impoundment. This option was named the "Mound Cover Surface" and is presented on Figure 9-6. This option results in a total volume of 2,820 CY, with 2,020 CY required for the cover and 800 CY remaining for waste disposal.

A third option was prepared assuming a convex upward surface mounded in the middle with 5H:1V side slopes. This option was named the "Raised Mound Cover Surface" and is presented on Figure 9-7. This option results in a total volume of 9,370 CY, with 3,700 CY required for the cover and 5,670 CY remaining for waste disposal.

9.1.3 *Summary of Pit Capacity*

EA prepared conceptual repository designs to determine the capacity of pits AUM 457 and 458 to receive mining wastes. With a convex upward mounded repository design AUM 458 could hold approximately 5,670 CY of removal material. With a convex upward surface down the middle of the impoundment the repository design at AUM 457 could hold approximately 1,560 CY of removal material. The potential pit capacities are summarized in Table 9-1.

9.2 WASTE VOLUMES

Page 5 of Appendix A of the Administrative Settlement Agreement and Order on Consent (AOC) (EPA, 2016a) states: *"Waste Volumes: Respondents shall calculate the volumes of contaminated soil and sediment with concentrations above the screening levels and with concentrations above the proposed risk based action levels."* This section of the report presents analyses to determine the volumes of contaminated soils above the investigation level (IL)/screening levels and the risk based action levels. Since the requirement is to calculate volumes of contaminated soils, only the soils deemed as TENORM on Figures 5-14 through 5-18 were used to determine volumes. The soils designated as NORM were not included in the volume estimates.

9.2.1 *Volumes Above IL*

The investigation levels for 1) horizontal correlations between exposure rate and static gamma count rate, and 2) vertical correlations between exposure rate and Ra-226 concentration in soil were discussed in Section 5.0 of this report. The correlation data are presented in Appendix B of the Phase III Summary Report (provided as Appendix M to this report). The horizontal and vertical correlations are summarized in Tables 9-2 and 9-3, respectively. The correlations were performed for the LCR, Drainage, and Alluvial Pooled Areas presented on Figure 5-13.

For the purpose of determining volumes in a desktop survey the mean correlation was used to determine a reasonable estimate of quantities. The goal of the volume estimate is not to estimate a conservative estimate, rather to estimate a most reasonable estimate for future use in an engineering evaluation/cost analysis (EECA) study.

Based upon the areas of TENORM, the mean horizontal correlation between IL and static gamma count rate for the pooled areas, and the static gamma count rates, the areas that exceeded IL for the surface horizontal surveys were determined. The areas that exceed the IL are presented on Figure 9-8. This data is sub-divided into four quadrants for further discussion in

the report, and to allow the data to be analyzed at a larger scale. The volume of material that exceed IL is 31,500 CY as shown presented on Figure 9-8. As defined in this report and the AOC, the IL is 1.24 pCi/g above background and has not been defined as a cleanup level. A summary of the waste volumes is provided in Table 9-4.

9.2.1.1 Volume Above IL – NW Quadrant

The areas that exceed the horizontal IL for the NW Quadrant are shown on Figure 9-9, as well as the test pit locations in the dozer push area. Based on the field investigation, soil sampling, and the vertical (test pit) correlations, the samples that exceeded the IL in Test Pit 1 reached a depth of 3 feet. This material was identified as material imported to the Site and disposed of in the dozer push area. Thus, the dozer push area that exceeded the horizontal IL was assumed to have a depth of 3 feet for the volume estimate. Other areas that exceeded the horizontal IL in the NW Quadrant are limited to surface soils sitting on top of bedrock and were assumed to have a depth of 0 to 2 inches with an average depth of 1 inch. The areas and depths for the NW Quadrant are presented on Figure 9-9. The volume of material that exceeds IL in this quadrant is 4,087 CY.

9.2.1.2 Volume Above IL – NE Quadrant

The areas that exceed the horizontal IL and the location of the test pits for the NE Quadrant are shown on Figure 9-10. The NE Quadrant contains AUM 457 and its related features consisting of the pit, pond, concrete slabs, waste rock piles, and upgrader foundations as shown on Figure 4-1. Based on the field investigation, soil sampling, the vertical (test pit) correlations, the aerial photography, and the Site topography, the areas that exceed the IL are shown on Figure 9-11. The estimated depth of soils that exceed IL are also shown on Figures 9-10 and 9-11. In general, the depth of soils above IL are estimated to be 1 foot for the slabs, 7 to 10 feet for the waste rock piles, 5 feet for the upgrader, 2.5 feet for the ponds, up to 5.5 feet for the drainage below the upgrader, 0.3 feet for the pit, and 0 to 2 inches with an average of one inch for the remaining soils that are on top of near surface bedrock. The volume of material that exceeds IL in this quadrant is 10,209 CY as shown on Figure 9-11.

9.2.1.3 Volume Above IL – SW Quadrant

The areas that exceed the horizontal IL and the location of the test pits for the SW Quadrant are shown on Figure 9-12. The SW Quadrant contains AUM 458 and its related features consisting of the pit, roads cuts, and dozer pushes as shown on Figure 4-2. Based on the field investigation, soil sampling, the vertical (test pit) correlations, the aerial photography, and the site topography, the areas that exceed the IL are shown on Figure 9-13. The estimated depths of the soils that exceed IL are also shown on Figures 9-12 and 9-13. In general, the depth of soils above IL are estimated to be 1 foot for the bottom of the pit, 1.5 feet for the road to the south, 5 feet for the dozer push areas, 1.5 feet for the alluvial areas to the east of the dozer push, and 0 to 2 inches, with an average of 1 inch for the remaining soils that are on top of near surface bedrock and excavated pit faces. The volume of material that exceeds IL in this quadrant is 7,818 CY as shown on Figure 9-13.

9.2.1.4 Volume Above IL – SE Quadrant

The areas that exceed the horizontal IL and the locations of the test pits for the SE Quadrant are shown on Figure 9-14. The SE Quadrant is north of the off-Site pit area located in AUM 459. Based on the field investigation, soil sampling and the vertical (test pit) correlations, the samples

that exceeded the IL are shown on Figure 9-14. In general, the depths of soils above IL are estimated to be 1 foot in the alluvium at the location of TP-15, 1 foot in the area of TP-17, and 3 feet in the alluvium drainage below AUM 459 (TP-23). Other areas that exceeded the horizontal IL in the SE Quadrant are limited to surface soils sitting on top of bedrock and were assumed to have a depth of 0 to 2 inches with an average of 1 inch. The areas and depths for the SE Quadrant are presented on Figure 9-15. The volume of material that exceeds IL in this quadrant is 9,436 CY as shown on Figure 9-14.

9.2.2 *Volume Above Proposed Risk Based Action Levels*

The rbALs are presented in Section 8.0 of this report. The rbAL for Ra-226 for the receptors presented in Section 6.13 was determined to range from 12 pCi/g (Long Term Adult Recreator and Child) to 160 pCi/g (On-Site Worker). The approved Phase II (horizontal) correlation between gamma count rate and Ra-226 concentration in soil was used to estimate the concentration of Ra-226 in supplemental gamma survey areas. The extents of TENORM gamma survey data that is potentially above the rbAL of 160 pCi/g for Ra-226 are shown on Figures 9-15 through 9-21. Areas with Ra-226 readings above the rbAL of 160 pCi/g are located within AUM 457 and 458. AUM 457 is located in the northeast area of the site and AUM 458 is located in the southwest area of the site. The volume of material above the rbAL of 160 pCi/g at AUM 457 was calculated to be 940 cubic yards and is presented on Figure 9-18. The depths of excavation ranged from one inch to 10 feet at AUM 457. The volume of material above the rbAL of 160 pCi/g at AUM 458 was calculated to be 2 cubic yards and is presented on Figure 9-20. The area above the rbAL of 160 pCi/g at AUM 458 are located in outcrop areas and thus an excavation depth of one inch was assumed.

The extents of TENORM gamma survey data that is potentially above the rbAL of 12 pCi/g for Ra-226 are shown on Figures 9-22 through 9-26. The volume of material above the rbAL of 12 pCi/g was calculated to be 10,036 cubic yards and is presented on Figures 9-23 through 9-26. The depths of excavation ranged from one inch to 10 feet.

The lateral extents and calculated volumes for the rbAL of 160 pCi/g and 12 pCi/g area shown on Figures 9-27 through 9-29. The there is no material calculated to be on Section 10 above the rbAL of 160 pCi/g. The amount of material above the rbAL of 12 pCi/g on Section 10 was calculated to be 634 cubic yards.

The depths of excavation that were used to calculate volumes for the material above the IL were also used to determine the depths of excavation for the material above the rbAL. Thus, the depths used to determine the volumes above the rbAL are conservative.

10.0 SUMMARY AND CONCLUSIONS

This RSE report presents the results of all the work completed under the AOC (EPA, 2016a) including the streamlined risk evaluations, and material volume estimates above the IL and risk-based action levels. This RSE meets the requirements presented in the AOC.

The HHSRE showed that the non-cancer risks from the non-radiological PCOCs in soils were below the level of regulatory concern and the cancer risks from arsenic and Ra-226 in soils were below the levels or within acceptable range of regulatory concern for all of the evaluated receptors and evaluated portions of the Site, except for Ra-226 at AUM 458. Based on the UCL soil concentrations, the latter showed calculated risks above $1x10^{-4}$ and also above the OSWER Directive 9200.4-18 value of $3x10^{-4}$ for the two of the three recreational receptors (adult only and combined adult plus child) but not for the other evaluated receptor (child recreator and site worker).

The EcoSRE showed that the potential risks were below EPA's level of regulatory concern for nearly all of the non-radiological PCOCs and Ra-226 to birds or mammals that utilize the evaluated portions of the Site. The exceptions were for molybdenum exposures to plants, and small mammals in AUM 458. For plants, molybdenum had HQ_{NOAEL} and HQ_{LOAEL} values above one using either the mean or UCL concentrations across most of the evaluated Site area (exception was the riparian area), and an HQ_{LOAEL} above one using the UCL soil concentration from AUM 458 only. However, this was likely not significant given that mean and UCL soil concentrations were within the range of the LOAEL values used to derive the TRV. Furthermore, the substrate (i.e., soil types and precipitation) particularly in the AUMs, would limit the establishment of plants in these areas. For the small herbivorous and insectivorous mammals (deer mouse and desert shrew, respectively) the UCL soil concentrations for molybdenum showed HQ_{NOAEL} and HQ_{LOAEL} values above one for AUM 458 only. Calculated risks from the other AUMs and evaluated areas were all below the regulatory level of concern.

The risk based action levels are presented in Section 8.0 of this report. The rbAL for Ra-226 for the receptors presented in Section 6.13 was determined to range from 12 pCi/g (Long Term Adult Recreator and Child) to 160 pCi/g (On-Site Worker). The extent of gamma survey data that is potentially above the rbAL for Ra-226 is shown on Figures 9-17 through 9-27. A summary of the volume of material based on the rbAL is provided below.

- The volume of material above the rbAL 160 pCi/g in the northeast quadrant (Figure 9-17) at AUM 457 was calculated to be 940 cubic yards and is presented on Figure 9-18. The there is no material calculated to be on Section 10 above the rbAL of 160 pCi/g.
- The volume of material above the rbAL 12 pCi/g in the northeast quadrant (AUM 457) was calculated to be 2,688 cubic yards and is presented on Figure 9-24. The amount of material above the rbAL of 12 pCi/g on Section 10 was calculated to be 634 cubic yards.
- No material above the rbAl of 160 pCi/g was encountered in the southeast quadrant as presented on Figure 9-21
- The volume of material above the rbAL 12 pCi/g in the southeast quadrant was calculated to be 647 cubic yards and it presented on Figure 9-26.
- The volume of material above the rbAL 160 pCi/g in the southwest quadrant (Figure 9-19) at AUM 458 was calculated to be 2 cubic yards and is presented on Figure 9-20.

- The volume of material above the rbAL 12 pCi/g in the southwest quadrant (AUM 458) was calculated to be 5,535 cubic yards and is presented on Figure 9-25.
- No material above the rbAl of 160 pCi/g was encountered in the northwest as presented on Figure 9-16
- The volume of material above the rbAL 12 pCi/g in the northwest quadrant was calculated to be 1,166 cubic yards and is presented on Figure 9-23.

The depths of excavation that were used to calculate volumes for the material above the IL were also used to determine the depths of excavation for the material above the rbAL. Thus, the depths used to determine the volumes above the rbAL are conservative.

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TABLES

Table 4-1 Summary Statistics for Gamma Count Rates (cpm) in the Background Study Areas

Background Study Area	Number of Measurements	Minimum	Maximum	Mean	Median	Standard Deviation	Relative Standard Deviation (%)
Alluvial BSA #1	2,046	39,595	50,613	45,668	45,595	1,649	3.61
Alluvial BSA #2	3,715	37,744	51,925	44,771	44,753	2,250	5.03
Drainage BSA #2	1,632	34,110	52,957	39,586	39,363	2,279	5.76
Little Colorado River BSA	3,641	19,679	30,180	23,190	22,983	1,372	5.92
EPA "Qter BRA"	1,432	33,106	45,860	38,676	38,612	1,877	4.85
Terrace BSA #1	1,567	32,658	56,560	40,191	39,481	3,728	9.27
Terrace BSA #2	1,169	36,168	48,685	41,106	41,089	1,744	4.24

cpm = counts per minute
All measurements were collected using a Ludlum model 44-20, a 3x3 inch sodium iodide detector.

Table 4-2 Survey Instruments for Transect Gamma Survey

System Identifier[1]	Channel	Date Range Used	Ludlum Detector		Ludlum Ratemeter	
			Model	Serial Number	Model	Serial Number
3	1	10/18/17 – 10/23/17	44-20	PR269980	4612	291488
3	2	10/18/17 – 10/23/17	44-20	PR269985	4612	291488
3	3	10/18/17 – 10/23/17	44-20	051517N	4612	291488
10	-	11/08/17 – 11/09/17	44-20	PR269985	2221	271435
11	-	10/20/17 – 11/09/17	44-20	PR262403	2221	218564
12	-	10/17/17 – 11/08/17	44-20	051517N	2221	271435
12(2)	-	11/07/17 – 11/09/17	44-20	051517S	2221	149940
13(2)	-	10/19/17 – 10/27/17	44-20	051517S	2221	149940
16	-	03/10/20	44-20	042911F2	2221	176952

[1]The identifier is used to distinguish the instrument pair used for specific measurements.
[2] The system identifier is only specific to the data logger used to collect the GPS gamma walkover data. During the demob and remob between 10/27/2017 and 11/06/2017 a different data logger was put into circulation and paired with the same 2221/44-20 pair.

Table 4-3 Survey Instrumentation used for the Concrete Survey

Date Range Used	Ludlum Detector		Ludlum Ratemeter	
	Model	Serial Number	Model	Serial Number
11/06/17	43-93	PR298426	2360	184965
11/06/17 – 11/07/17	43-93	PR339054	2360	215279
11/06/17 – 11/09/17	43-93	PR199838	2360	278586

Table 4-4 Soil and Sediment Sample Location Rationale

Test Pit ID	Rationale	Selection Criteria
TP-1	Excavation to determine the depth of impacted material in the dozer push area at the north of the site.	General location in the TENORM area. Professional judgment used.
TP-2	Excavation in the EPA identified drainage north of AUM 457 to determine the depth of impacted material.	General location in center of the Drainage area where sediments are anticipated to be the deepest. Professional judgment used.
TP-3	Excavation in TENORM area within AUM 457 to determine the depth of impacted material.	Pit at the north of AUM 457. Professional judgment used.
TP-4	Excavation in bottom of the pond area within AUM 457 to determine the depth of impacted material.	Center of the pond where sediments are anticipated to be the deepest. Professional judgment used.
TP-5	Excavation in TENORM area within AUM 457 to determine the depth of impacted material.	West side of AUM 457 in TENORM area. Professional judgment used.
TP-6	Excavation in berm around the pond area within AUM 457 to determine the depth of impacted material.	Top of the berm around the pond area. Professional judgment used.
TP-7	Excavation in the drainage downgradient of the up-grader foundation within AUM 457 to determine the depth of impacted material.	Area is directly downgradient of the upgrader and anticipated to the area of deepest sediment. Professional judgment used.
TP-8	Excavation in the drainage downgradient of the up-grader foundation within AUM 457 to determine the depth of impacted material.	Area is directly downgradient of the upgrader and anticipated to the area of deepest sediment. Professional judgment used.
TP-9	Excavation in at the northwestern edge of Wetlands Area 3 and downgradient of the up-grader foundation within AUM 457 to determine the depth of impacted material.	Area is directly downgradient of the upgrader and anticipated to the area of deepest sediment. Professional judgment used.
TP-10	Excavation in the TENORM area within AUM 457 to determine the depth of impacted material.	Access road to AUM 457. Professional judgment used. Location may be adjusted to account for field conditions.
TP-11	Excavation in at the western edge of Wetlands Area 3.	Test pit is provided to bound Wetlands Area 3. Professional judgment used.

Table 4-5 Survey Instruments for Subsurface Gamma Profiling

Ludlum Detector		Ludlum Ratemeter/Data Logger		Date Range Used	Notes
Model	**Serial Number**	**Model**	**Serial Number**		
43-93	PR299677	2360	215282	12/3/18 – 12/4/18	Used to prepare sample shipment.
43-93	PR292138	2360	277007	12/5/18 – 12/6/18	Used to prepare sample shipment.
19	180310	N/A		12/3/18 – 12/6/18	Used to prepare sample shipment.
44-10	PR355764	2221	262347	12/3/18 – 12/6/18	Used to quantify static shielded gamma count rate of trench samples.

[1]The identifier is used to distinguish the instrument pair used for specific measurements.

Table 4-6 Analytes and Methods for Surface Soil and Sediment Samples

Analyte Group	Analyte[1]	Analytical Method[2]	Anticipated Concentration Range	Method Detection Limit[3]	Laboratory CRQL[3]
Metals and Metalloids	Arsenic	EPA 6020	2-250 mg/kg	0.0036 mg/kg	0.2 mg/kg
	Mercury	EPA 7471B	0.01-10 mg/kg	0.00005 mg/kg	0.033 mg/kg
	Molybdenum	EPA 6010	5-2000 mg/kg	0.47 mg/kg	1.0 mg/kg
	Selenium	EPA 6010	2-50 mg/kg	0.3 mg/kg	0.5 mg/kg
	Uranium	EPA 6020	0.1-350 mg/kg	0.0018 mg/kg	0.01 mg/kg
	Vanadium	EPA 6010	10-400 mg/kg	0.2 mg/kg	1.0 mg/kg
Radionuclides	Ra-226	EPA 901.1M	0.5-1,000 pCi/g	NA	0.25 pCi/g

[1]The Potential Contaminants of Concern (PCOCs) are identified in Section 1.2 of Appendix A to the AOC (EPA, 2016a).
[2]EPA Method 6010 and 6020 analyses require digestion via EPA Method 3050B.
[3]CRQL = Contract Required Quantitation Limit. Depending upon sample matrix, the actual sample detection limit may vary.

Table 4-7 Summary Statistics for Concentrations of Ra-226 (pCi/g) in Samples of Surface Soils Obtained in the Background Study

Background Study Area	Number of Samples	Minimum	Maximum	Mean	Median	Standard Deviation
Alluvial BSA #1	7	1.57	3.59	2.54	2.44	0.67
Alluvial BSA #2	15	1.63	5.43	2.73	2.69	0.94
Drainage BSA #2	6	1.04	1.71	1.27	1.21	0.24
Little Colorado River BSA	11	0.55	1.26	0.85	0.83	0.2
EPA "Qter BRA"	10	1.52	2.98	1.99	1.87	0.4
Terrace #1	10	1.33	2.64	2.03	1.95	0.38
Terrace #2	10	2.05	3.72	2.4	2.25	0.49

pCi/g = picocuries per gram

Table 4-8 Summary Statistics for Concentrations of Arsenic (mg/kg) in Samples of Surface Soils Obtained in the Background Study

Background Study Area	Number of Samples	Minimum	Maximum	Mean	Median	Standard Deviation
Alluvial BSA #1	7	2.30	2.90	2.54	2.50	0.21
Alluvial BSA #2	15	2.80	3.70	3.36	3.40	0.30
Drainage BSA #2	6	2.90	3.50	3.20	3.20	0.24
Little Colorado River BSA	11	1.50	2.40	1.90	1.90	0.29
EPA "Qter BRA"	10	3.00	5.00	4.05	4.25	0.70
Terrace BSA #1	10	1.00	3.40	2.09	2.10	0.84
Terrace BSA #2	10	1.80	4.90	2.88	2.80	0.80

mg/kg = milligrams per kilogram
For the sample results reported as below the MDL, the sample's MDL was used to calculate the summary statistics.

Table 4-9 Summary Statistics for Concentrations of Mercury (mg/kg) in Samples of Surface Soils Obtained in the Background Study

Background Study Area	Number of Samples	Minimum	Maximum	Mean	Median	Standard Deviation
Alluvial BSA #1	7	0.0054	0.017	0.0081	0.0066	0.0040
Alluvial BSA #2	15	0.0039	0.01	0.00656	0.0065	0.0017
Drainage BSA #2	6	0.0041	0.009	0.00633	0.0058	0.00202
Little Colorado River BSA	11	0.0014	0.0052	0.0035	0.0038	0.00111
EPA "Qter BRA"	10	0.011	0.019	0.0158	0.016	0.00249
Terrace BSA #1	10	0.0048	0.02	0.0112	0.011	0.00403
Terrace BSA #2	10	0.0059	0.011	0.00936	0.0098	0.00169

mg/kg = milligrams per kilogram
For the sample results reported as below the MDL, the sample's MDL was used to calculate the summary statistics.

Table 4-10 Summary Statistics for Concentrations of Molybdenum (mg/kg) in Samples of Surface Soils Obtained in the Background Study

Background Study Area	Number of Samples	Minimum	Maximum	Mean	Median	Standard Deviation
Alluvial BSA #1	7	0.18	0.63	0.39	0.42	0.17
Alluvial BSA #2	15	0.18	0.59	0.294	0.24	0.13
Drainage BSA #2	6	0.17	0.36	0.215	0.18	0.0731
Little Colorado River BSA	11	0.18	0.25	0.199	0.19	0.0207
EPA "Qter BRA"	10	0.18	0.34	0.216	0.19	0.0604
Terrace #1	10	0.17	0.54	0.254	0.19	0.113
Terrace #2	10	0.18	0.53	0.365	0.35	0.105

mg/kg = milligrams per kilogram
For the sample results reported as below the MDL, the sample's MDL was used to calculate the summary statistics.

Table 4-11 Summary Statistics for Concentrations of Selenium (mg/kg) in Samples of Surface Soils Obtained in the Background Study

Background Study Area	Number of Samples	Minimum	Maximum	Mean	Median	Standard Deviation
Alluvial BSA #1	7	0.24	0.63	0.33	0.28	0.14
Alluvial BSA #2	15	0.23	1.9	0.545	0.44	0.454
Drainage BSA#2	6	0.22	0.68	0.37	0.29	0.187
Little Colorado River BSA	11	0.23	0.28	0.248	0.24	0.016
EPA "Qter BRA"	10	0.23	0.51	0.342	0.26	0.126
Terrace BSA #1	10	0.23	0.69	0.344	0.24	0.162
Terrace BSA #2	10	0.23	0.47	0.265	0.245	0.0725

mg/kg = milligrams per kilogram
For the sample results reported as below the MDL, the sample's MDL was used to calculate the summary statistics.

Table 4-12 Summary Statistics for Concentrations of Uranium (mg/kg) in Samples of Surface Soils Obtained in the Background Study

Background Study Area	Number of Samples	Minimum	Maximum	Mean	Median	Standard Deviation
Alluvial BSA #1	7	2.3	3.0	2.6	2.6	0.23
Alluvial BSA #2	15	1.9	3.9	2.69	2.6	0.53
Drainage BSA #2	6	0.93	1.5	1.27	1.3	0.21
Little Colorado River BSA	11	0.47	0.76	0.63	0.66	0.09
EPA "Qter BRA"	10	1.8	3.5	2.23	2.15	0.5
Terrace BSA #1	10	1.2	2.3	1.68	1.65	0.35
Terrace BSA #2	10	3.1	5.4	3.99	4	0.68

mg/kg = milligrams per kilogram
For the sample results reported as below the MDL, the sample's MDL was used to calculate the summary statistics.

Table 4-13 Summary Statistics for Concentrations of Vanadium (mg/kg) in Samples of Surface Soils Obtained in the Background Study

Background Study Area	Number of Samples	Minimum	Maximum	Mean	Median	Standard Deviation
Alluvial BSA #1	7	59	85	70.7	68	9.2
Alluvial BSA #2	15	58	90	71.2	70	9.6
Drainage BSA #2	6	31	35	33.5	34	1.8
Little Colorado River BSA	11	11	17	13.18	13	2.0
EPA "Qter BRA"	10	60	88	69.6	70	8.4
Terrace BSA #1	10	13	41	24.8	21	8.9
Terrace BSA #2	10	22	46	38.7	40	7.1

mg/kg = milligrams per kilogram
For the sample results reported as below the MDL, the sample's MDL was used to calculate the summary statistics.

Table 4-14 Summary Statistics for Constituents (n=11) for the Drainage BSA #2 (2017 and 2018 Data Set)

Constituent	Unit	Minimum	Maximum	Mean	Median	Standard Deviation
Arsenic	mg/kg	2.0	3.5	2.8	2.9	0.5
Mercury	mg/kg	0.00006	0.009	0.0036	0.0041	0.0035
Molybdenum	mg/kg	0.04	0.36	0.18	0.18	0.09
Ra-226	pCi/g	0.94	1.71	1.22	1.19	0.2
Selenium	mg/kg	0.049	0.68	0.23	0.22	0.21
Uranium	mg/kg	0.91	1.5	1.2	1.2	0.20
Vanadium	mg/kg	28.0	35.0	32.2	32.0	2.3

mg/kg = milligrams per kilogram
pCi/g = picocuries per gram
For the sample results reported as below the MDL, the sample's MDL was used to calculate the summary statistics.

Table 5-1 Data Validation Assessment of Relevant Field Data for Phase II Background Soil Sampling

Validation Requirement Met?	Validation Requirement	Supplemental Requirements	Qualifiers	Samples Affected	Comments
I. Relevant Field Data Review					
Yes	All data components are present.	*Including the COCs, copy of field logbook or other field notes.*	None		
No	The internal COC is complete with respect to all required form entries.	A complete and accurate custody log is recorded.	None	All samples in batch #1711413	The COC field "Relinquished by" is empty. The relinquisher Sam Paterniti was contacted and confirmed that the samples never left his custody until the samples were received by FedEx. Furthermore, Mr. Paterniti applied a custody seal to the shipping container that arrived intact. The COCs in every other batch were signed. This was confirmed by the "Condition of Sample Upon Receipt" Form provided by ALS Labs.
No	The internal COC is complete with respect to all required form entries.	*Field data and sample preservation information.*	None	BGS-T110-0-10-102617Rin, BGS-D105-0-15-102617Rin	BGS-T110-0-10-102617Rin and BGS-D105-0-15-102617Rin, both field rinsate samples, were unpreserved. These rinsate samples should have been preserved with nitric acid or delivered to the laboratory within 5 days of collection in accordance with EPA Method 900.0. This preservation method was not identified in the QAPP or FSP. Lack of preservation is unlikely to affect result since this is a low level field rinsate sample.
Yes		*Identification of requested analyses.*	None		
Yes		*References to any special or non-routine sampling, handling, or analysis requirements.*	None		
N/A		*Any attached supporting records containing additional sample relevant information.*			Only the COC was submitted to the laboratory.

Table 5-1 Data Validation Assessment of Relevant Field Data for Phase II Background Soil Sampling (Continued)

Validation Requirement Met?	Validation Requirement	Supplemental Requirements	Qualifiers	Samples Affected	Comments
I. Relevant Field Data Review					
Yes	Sample collection was complete and followed the QAPP, applicable FSP, SOP, or work plan.		None	All samples in batch #1711413	There was an addition implemented to the soil sample nomenclature to account for multiple BSAs. This addition was approved by the Radiological Technical Team Lead, Mike Schierman. Please refer to Tyler Alecksen's logbook dated 11/16 for further detail.
Yes	Equipment Rinsate Blank	*There is at least one blank for every 20 samples or one on each day.*	None		
		The concentration of the blank is less than or equal to the required detection limit.	R	BGS-T110-0-10-102617Rin, BGS-D105-0-15-102617Rin	Based on discussion with EPA, the all rinsate samples were qualified with "R" (rejected) due to deviations of preservation from EPA Method 900.0
Yes	Field Duplicate	*At least one duplicate sample was collected per 20 samples or one per sampling event, which ever was more frequent.*	None		
		The duplicate samples were a split of one of the original samples.	None		

Table 5-1 Data Validation Assessment of Relevant Field Data for Phase II Background Soil Sampling (Continued)

Validation Requirement Met?	Validation Requirement	Supplemental Requirements	Qualifiers	Samples Affected	Comments
I. Relevant Field Data Review					
Yes	Field Duplicate	*When the average of the analytical results (the duplicate pairs) is greater than or equal to the UBGR, ($\bar{x} > 0.5$), the relative percent difference (RPD) must be less than 127% for samples from Background Study Areas.*	None	BGS-D105-0-15-102617S, BGS-D105-0-15-102617Dup; BGS-T110-0-10-102617S, BGS-T110-0-10-102617Dup.	All field duplicates in batch #1711413 originated in Background Study Areas. All duplicates averages were greater than 0.5 pCi/g and met their respective Measurement Quality Objective for precision.

Table 5-2 Data Validation Assessment of Analytical Lab Data for Phase II Background Soil Sampling

Validation Requirement Met?	Validation Requirement	Supplemental Requirements	Qualifiers	Samples Affected	Comments
Yes	Holding Times Met?	*Was the lab in compliance with the prescribed holding time allowance of 6 months.*	None	All samples	Mercury was analyzed on the same day the soils samples were extracted.
Yes	Condition of Samples Upon Receipt	*Was the custody seal on the shipping container intact?*	None	All samples	All details were provided by ALS labs in the "Condition of Sample Upon" receipt form. In batch 1711418, sample 458-3-0-15-110617S was broken upon arrival.
		Was the received COC in agreement with samples received?			
		Was there sufficient sample for the requested analysis?			
		Were all sample containers received intact?			
Yes	Appropriate Methods	*All analytical laboratory procedures for this project shall use EPA approved methods in accordance with the QAPP / FSP.*	J	All samples	Soil samples for Mo, Se, V, As and U extracted via SW846 Method 3050. Mo, Se and V analyzed via SW846 Method 6010. As and U analyzed via SW846 Method 6020. Hg extracted and analyzed via SW846 Method 7471. Due to rejection of rinstae blank data resulting from improper rinstae sample preservation, it was agreed that all analytical data weould be qualified with "J" to identify that the absence of cross contamination between samples could not be completely verified.
Yes	Calibration Okay	*Laboratory instrument calibration methods and frequency will be performed per the laboratory's*	None	All samples	Documentation of calibration included in reports. Expiration dates of standards okay. All ICV/CCV standard results within control limits. Several ICP ICB/CCB samples reported slight negative values or values just above the MDL, but less than the CRDL.

Table 5-2 Data Validation Assessment of Analytical Lab Data for Phase II Background Soil Sampling (Continued)

Validation Requirement Met?	Validation Requirement	Supplemental Requirements	Qualifiers	Samples Affected	Comments
Yes	Method Blanks (MB)	*QA manual and SOPs.*	None	All Samples	V, As and U not present any of the 7 MBs. Mo reported as negative value in 1 of 7 MBs. Se reported just above MDL in 2 of 7 MBs. Hg reported as negative in 5 of 7 MBs and just above MDL in 2 of 7 MBs. All positive values < CRQL.
Yes	Lab Control Samples (LCS)	*At least one LCS is analyzed per every 20 samples in a batch.*	None	All Samples	Frequency requirement met.
		Are the recovery limits met (75% to 125%).	None	All Samples	All LCS results within control limits.
Partially	Spikes Recovery Limits Met	*The matrix spike control limits are 75%-125% Recovery and |RPD| <20%unless otherwise specified by the laboratory.*	U in 30 samples in Prep Batches IP171221-2 and -5 qualified as estimated ("J"). Qualification for Mo in one sample changed from U to UJ.	All Samples	All 6 MS/MSD pairs for V, As and Hg within control limits. One MS/MSD pair for Mo and Se outside of control limits. Two of six MS/MSD pairs exhibited uranium values outside of control limits.

Table 5-2 Data Validation Assessment of Analytical Lab Data for Phase II Background Soil Sampling (Continued)

Validation Requirement Met?	Validation Requirement	Supplemental Requirements	Qualifiers	Samples Affected	Comments
N/A	Total Propagated Uncertainty	*The TPU for each sample falls below the maximum acceptable TPU for Ra-226*			Not applicable for metals analyses.
Yes	Laboratory Duplicates	*If both results > 5x CRDL, |RPD| <20%*		All samples.	Se, V and As within control limits of all six laboratory duplicates. Mo and U within control limits in 5 of 6 laboratory duplicates each.
Yes	Reporting Limits/Quantitation Limits Met	*All analytical results exceed the CRQL.*		All Samples	Mo okay. MDLs of As and V above Project MDL in a few samples, but metals concentrations above MDL. MDL of U above Project MDL in all samples, but U concentrations above MDL. MDL for Se in 4 samples above Project MDL and values for these 4 samples reported below MDL ("U").
Yes	Completeness	*Completeness is assessed by the ratio of fully usable data points to the total number of data points. The ratio must exceed 95%.*		All samples	101 samples and 6 metals for 606 total data points. One sample container broke in transit (-6). No sample values rejected. Completeness = 600/606 = 99%.

Table 5-3 Data Validation Assessment of Relevant Field Data for Phase III Soil Sampling

Data	Data Quality Indicator	Sample or Measurement	Validation Requirement	Validation Result	Comments
Logs	All components of data are present	--	COCs, field logbooks, field notes are present	PASS	
	COCs complete and accurate	--	Complete and accurate custody log	FAIL	Errors found in dates and times of some samples. Sample traceability unaffected.
Field	Sample collection complete	All	Samples collected according to QAPP, FSP, SOPs, and/or Work Plan	PASS	
	SOPs followed	All	Field guidance follows SOP	PASS	
	Preservation met	All	Samples preserved according to QAPP and/or FSP	PASS	
	Equipment Blanks Clean	Rinsates	Blank nuclide concentrations are below quantitation level	FAIL	Drain-TP16-RINSE-120318 contained detectable gross α.
	Field Duplicates FPD / RD / AD	Field duplicates	At least one duplicate sample collected per 20 samples or one per sampling event, whichever was more frequent	PASS	

Table 5-4 Data Validation Assessment of Analytical Lab Data for Phase III Background Soil Sampling

Data	Data Quality Indicator	Sample or Measurement	Validation Requirement	Validation Result	Comments
Lab	Holding Times Met	All	Sample hold times meet QAPP and/or FSP requirements	PASS	
	Appropriate Methods	All	Procedures use EPA approved methods in accordance with the QAPP and/or FSP	PASS	
	Calibration OK	--	The laboratory followed calibration procedures	PASS	
	Blanks Clean	Blanks	Laboratory blanks are below quantitation level	PASS	Detectable concentrations were measured for gross α, but no validation requirements exist. For the metals analyses performed via ICP, negative results were reported for several calibration blank and method blanks. However, a bias was determined not to be present.

Table 5-4 Data Validation Assessment of Analytical Lab Data for Phase III Background Soil Sampling (Continued)

Data	Data Quality Indicator	Sample or Measurement	Validation Requirement	Validation Result	Comments
	Lab Control Samples (LCS) Recovery Limit Met	LCS/QC Standards	%D < control limit of 81%	PASS	
	Spikes Recovery Limits criteria met	Matrix Spikes/Matrix Spike Duplicates (Metals only)	The matrix spike control limits are 75%-125% Recovery and |RPD| <20% unless otherwise specified by the laboratory	PARTIALLY	The results for the arsenic matrix spike/matrix spike duplicate samples 1812316-26MS and 1812316-26MSD were below the lower control limit. EA will qualify the arsenic results from the Project samples associated with QC samples 1812316-26MS and 1812316-26MSD (ALS "Prep Batch" IP190109-5) as estimated ("J" qualifier).
	Duplicate RPD / RD / AD	Laboratory duplicates	At least one LCS is analyzed per 20 samples in a batch	PASS	Sample volumes were insufficient to allow preparation of a duplicate. Duplicate analysis of Samples 1812316-5, -29, and -53 performed in lieu of a prepared duplicate.
	Reporting Limits / Quantitation Limits Met	All	Analytical results exceed quantitation limits	PASS	Many Minimum Detectable Concentrations (MDCs) are above the requested MDC but meet the acceptance criteria for uncertainty.

Table 5-4 Data Validation Assessment of Analytical Lab Data for Phase III Background Soil Sampling (Continued)

Data	Data Quality Indicator	Sample or Measurement	Validation Requirement	Validation Result	Comments
Sample and Analytical Potential TENORM	Accuracy / Bias	LCS/QC Standards	%D < control limit of 81%	PASS	
	Accuracy / Bias / Sensitivity-Contamination	Matrix Blanks	Analyte control limit of ±0.45 pCi/g	PASS	
	Precision	Lab Duplicates	RPD ≤ 113% for $\bar{x}$ > UBGR, or AD < 2.54 pCi/g for $\bar{x}$ < UBGR	PASS	
	Precision	Field Duplicates	RPD ≤ 113% for $\bar{x}$ > UBGR, or AD < 2.54 pCi/g for $\bar{x}$ < UBGR	PASS	
	Completeness	All Data	Usable data > 95% all data	PASS	
	Total Propagated Uncertainty (TPU)	--	TPU < calculated TPU limit	PASS	

Table 5-4 Data Validation Assessment of Analytical Lab Data for Phase III Background Soil Sampling (Continued)

Data	Data Quality Indicator	Sample or Measurement	Validation Requirement	Validation Result	Comments
Sample and Analytical Background Study Areas	Accuracy/Bias	LCS/QC Standards	%D < control limit of 81%	PASS	
	Accuracy / Bias / Sensitivity-Contamination	Matrix Blanks	Control limit of ±0.45 pCi/g	PASS	
	Precision	Lab Duplicates	RPD ≤ 127% for $\bar{x}$ > UBGR, or AD < 2.54 pCi/g for $\bar{x}$ < UBGR	PASS	
	Precision	Field Duplicates	RPD ≤ 127% for $\bar{x}$ > UBGR, or AD < 2.54 pCi/g for $\bar{x}$ < UBGR	PASS	
	Completeness	All Data	Usable data > 95% all data	PASS	
	Total Propagated Uncertainty	--	TPU < calculated TPU limit	PASS	

Table 5-5 Description of Measurement Type and Analytic Technique/Equipment used for the Phase II Correlation Study

Measurement Type	Report Unit	Equipment Used
Exposure Rate	μR / hr	High Pressure Ionization Chamber Reuter-Stokes Serial #1000992
Soil Ra-226 Concentration	pCi / g	Laboratory Analysis EPA 901.1m
Static Gamma Count Rate	cpm	44-20 3x3" NaI(Tl) Serial #051517N Ludlum Model 2221 Ratemeter (serial# 271435)
Dynamic Gamma Count Rate	cpm	44-20 3x3" NaI(Tl) Serial # PR262403 Ludlum Model 2221 Ratemeter Serial # 218564 44-20 3x3" NaI(Tl) Serial # 051517S Ludlum Model 2221 Ratemeter Serial # 149940 44-20 3x3" NaI(Tl) Serial # 051517N Ludlum Model 2221 Ratemeter Serial # 271435

Table 5-6 Gamma Count Rates and Associated Concentrations of Ra-226 in Samples of Surface Soils obtained in the Phase II Correlation Study

Gamma Count Rate (cpm)							Ra-226 (pCi/g)		
Location	**n**	**Mean**	**Minimum**	**Maximum**	**Standard Deviation**	**Relative Standard Deviation (%)**	**Result**	**Error ±2σ**	**MDL**
Correlation 1	72	33,100	29,586	38,192	1,537	4.64	1.94	0.31	0.33
Correlation 2	153	37,874	35,780	40,725	893	2.36	1.41	0.24	0.33
Correlation 3	218	77,951	62,393	87,956	4,428	5.68	6.97	0.89	0.43
Correlation 4	124	49,756	45,496	53,788	1,636	3.29	2.21	0.32	0.28
Correlation 5	103	56,257	51,027	60,530	1,807	3.21	3.75	0.50	0.29
Correlation 6	131	64,745	60,283	71,365	2,092	3.23	3.55	0.48	0.35
Correlation 7	115	81,035	70,248	94,754	5,734	7.08	6.32	0.78	0.27
Correlation 8	140	103,936	83,616	113,894	5,252	5.05	11.4	1.40	0.50
Correlation 9	166	144,964	127,087	176,490	8,357	5.76	11.9	1.40	0.40

cpm = counts per minute
MDL = method detection limit
n = number of samples
pCi/g = picocuries per gram
σ = standard deviation

Table 5-7 Co-Located: Soil Ra-226 Concentrations, Static Gamma Count Rate, and Exposure Rate Measurements

Location	Ra-226 Result (pCi/g)	Ra-226 Error ±2σ (pCi/g)	Ra-226 MDL (pCi/g)	Exposure rate (µR/hr)	Static gamma count rate (cpm)
Correlation 1	1.94	0.31	0.33	12.3	29,562
Correlation 2	1.41	0.24	0.33	14.1	38,949
Correlation 3	6.97	0.89	0.43	24.1	81,318
Correlation 4	2.21	0.32	0.28	15.0	44,924
Correlation 5	3.75	0.50	0.29	17.1	51,691
Correlation 6	3.55	0.48	0.35	18.8	66,269
Correlation 7	6.32	0.78	0.27	24.0	92,741
Correlation 8	11.4	1.40	0.50	26.6	95,872
Correlation 9	11.9	1.40	0.40	38.1	136,766

cpm = counts per minute
MDL = method detection limit
pCi/g = picocuries per gram
σ = standard deviation
µR/hr = micro-Roentgens per hour

Table 5-8 Adjusted r^2 Values for Regression of Non-Radiological Constituents on Ra-226, a surrogate for Gamma Data

Pool	Constituent	Adjusted r^2
BSA	Arsenic	0.11
BSA	Mercury	0.09
BSA	Molybdenum	0.19
BSA	Selenium	0.009
BSA	Uranium	0.46
BSA	Vanadium	0.37
Correlation	Arsenic	0.65
Correlation	Mercury	0.69
Correlation	Molybdenum	0.75
Correlation	Selenium	-0.14
Correlation	Uranium	0.54
Correlation	Vanadium	0.22

Table 5-9 Summary of Soil Sample Results

TEST PIT/Sample ID	Location	Depth	Sample Date	Sample Type	Constituent						
					Ra-226 pCi/g	Mercury (mg/kg)	Arsenic (mg/kg)	Uranium (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Vanadium (mg/kg)
TP14	AUM 457	0 - 0.5	12/03/18	Soil	2.94	0.00006	0.94	1.4	0.58	0.32	4
TP14-DUP	AUM 457	0 - 0.5	12/03/18	Soil	2.93	0.000057	0.97	1.4	0.55	0.051	3.6
TP15	AUM 457	0.5 - 1	12/06/18	Soil	7.54	0.026	6.6	5.7	6.7	0.055	9.2
TP15	AUM 457	0 - 0.5	12/06/18	Soil	8.2	0.02	9.9	6.7	30	0.054	15
TP3	AUM 457	0 - 0.5	12/04/18	Soil	12.1	0.015	14	8	35	0.092	27
TP3-DUP	AUM 457	0 - 0.5	12/04/18	Soil	12.5	0.018	17	19	25	0.054	24
TP4	AUM 457	2 - 2.5	12/04/18	Soil	5.92	0.0095	2.4	5.6	4.3	0.053	29
TP4	AUM 457	3 - 3.5	12/04/18	Soil	2.46	0.00006	2	3.4	2.8	0.054	22
TP5	AUM 457	0.5 - 1	12/04/18	Soil	1.93	0.000064	2.4	2	1.4	0.18	39
TP5	AUM 457	0 - 0.5	12/04/18	Soil	3	0.000064	2.6	4.5	3.6	0.055	39
TP6	AUM 457	0 - 0.5	12/04/18	Soil	1.76	0.000058	2	2.7	3	0.26	27
TP6	AUM 457	1 - 1.5	12/04/18	Soil	1.61	0.000061	1.8	1.6	0.71	0.048	32
RINSE	AUM 457	N/A	12/04/18	Water	Gross Alpha 0.67 pCi/L						
RINSE	AUM 457	N/A	12/04/18	Water	Gross Beta 1.2 pCi/L						
TP18	AUM 458	0.5 - 1	12/05/18	Soil	14	0.071	19	15	72	0.74	12
TP18	AUM 458	2 - 2.5	12/05/18	Soil	4.08	0.017	5.3	6.8	12	0.052	13
TP19	AUM 458	0.5 - 1	12/05/18	Soil	126	0.54	55	140	820	0.46	13
TP19	AUM 458	0 - 0.5	12/05/18	Soil	73.9	0.21	30	110	350	0.53	17
TP20	AUM 458	0.5 - 1	12/05/18	Soil	24.1	0.16	30	44	160	0.21	8.1
TP20	AUM 458	0 - 0.5	12/05/18	Soil	6.18	0.1	18	12	22	0.14	17
TP20	AUM 458	1 - 1.5	12/05/18	Soil	19.8	0.26	39	42	130	0.7	7.9
TP21	AUM 458	0.5 - 1	12/05/18	Soil	5.64	0.074	23	8.3	23	0.3	19
TP21	AUM 458	0 - 0.5	12/05/18	Soil	6.88	0.04	8.5	9.3	14	0.049	12
RINSE	AUM 458	N/A	12/05/18	Water	Gross Alpha 0.6 pCi/L						
RINSE	AUM 458	N/A	12/05/18	Water	Gross Beta -0.1 pCi/L						
TP23	AUM 459	0.5 - 1	12/06/18	Soil	19.7	0.032	8.2	15	55	0.17	9.8
TP23	AUM 459	0 - 0.5	12/06/18	Soil	15.9	0.019	7.1	8.3	52	0.047	6.7
TP23-DUP	AUM 459	0 - 0.5	12/06/18	Soil	14	0.0069	7.4	9.7	38	0.053	5.5
TP23	AUM 459	2.5 - 3	12/06/18	Soil	10.1	0.02	8.3	8.9	28	0.056	13
207	BGS	0 - 0.5	12/05/18	Soil	1.26	0.000061	2.4	1.1	0.037	0.054	33
207-DUP	BGS	0 - 0.5	12/05/18	Soil	1.14	0.000059	2.4	1.2	0.049	0.053	29
208	BGS	0 - 0.5	12/05/18	Soil	0.94	0.000061	2.4	0.91	0.14	0.055	31
209	BGS	0 - 0.5	12/05/18	Soil	1.19	0.000061	2.2	1	0.26	0.049	31
209	BGS	0 - 0.5	12/05/18	Soil	1.22	0.000058	2.2	1.1	0.27	0.05	30
210	BGS	0 - 0.5	12/05/18	Soil	1.28	0.00017	2.3	1.2	0.079	0.052	30

Table 5-9 Summary of Soil Sample Results (Continued)

TEST PIT/Sample ID	Location	Depth	Sample Date	Sample Type	Constituent						
					Ra-226 pCi/g	Mercury (mg/kg)	Arsenic (mg/kg)	Uranium (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Vanadium (mg/kg)
210	BGS	0 - 0.5	12/05/18	Soil	1.37	0.000057	2.6	1.3	0.062	0.052	32
211	BGS	0 - 0.5	12/05/18	Soil	1.29	0.0013	2	1.4	0.19	0.051	28
D207	BGS	0 - 0.5	12/05/18	Soil	1.14	0.000061	2.4	1.1	0.077	0.053	30
D207	BGS	0 - 0.5	12/05/18	Soil	1.07	0.00006	2.2	1.2	0.18	0.05	31
D208	BGS	0 - 0.5	12/05/18	Soil	1.24	0.000061	2.3	0.97	0.062	0.053	31
D211	BGS	0 - 0.5	12/05/18	Soil	1.3	0.000061	2	1.5	0.19	0.048	28
TP16	Drain	0 - 0.5	12/03/18	Soil	1.23	0.000058	1.7	1.3	0.27	0.051	24
TP16	Drain	1 - 1.5	12/03/18	Soil	1.2	0.000062	2	1.3	0.2	0.052	29
TP16	RINSE	N/A	12/03/18	Water	Gross Alpha 13.6 pCi/L						
TP16	RINSE	N/A	12/03/18	Water	Gross Beta 4.8 pCi/L						
TP2	Drain	0.5 - 1	12/04/18	Soil	2.82	0.0065	3.7	3.4	3.5	0.051	41
TP2	Drain	1 - 1.5	12/04/18	Soil	2.69	0.0012	3.4	3.9	2.1	0.058	42
TP7	Drain	0 - 0.5	12/04/18	Soil	5.71	0.000062	2.7	6	18	0.12	19
TP7	Drain	1 - 1.5	12/04/18	Soil	1.69	0.000058	1.7	3.6	7.9	0.15	17
TP8	Drain	0.5 - 1	12/04/18	Soil	31.3	0.028	12	21	53	0.23	23
TP8	Drain	0 - 0.5	12/04/18	Soil	37.5	0.019	6.3	14	37	0.32	25
TP8	Drain	2.5 - 3	12/04/18	Soil	1.76	0.000059	2.2	2.8	6.5	0.057	21
TP11	LCR	2 - 2.5	12/03/18	Soil	1.81	0.0099	2.4	1.5	0.77	0.061	23
TP12	LCR	0 - 0.5	12/03/18	Soil	1.48	0.000071	2.4	1.8	0.71	0.06	25
TP12	LCR	1 - 1.5	12/03/18	Soil	1.86	0.0089	2.6	2	0.71	0.056	26
TP9	LCR	2 - 2.5	12/03/18	Soil	58.2	0.17	10	28	78	0.047	16
TP9	LCR	3 - 3.5	12/03/18	Soil	55.7	0.16	7.9	37	34	0.074	21
TP9	LCR	4.5 - 5	12/03/18	Soil	7.37	0.028	3.6	16	18	0.063	22
TP9	RINSE	N/A	12/03/18	Water	Gross Alpha 2.1 pCi/L						
TP9	RINSE	N/A	12/03/18	Water	Gross Beta 6.9 pCi/L						
TP9	RINSE	N/A	12/04/18	Water	Gross Alpha 1.5 pCi/L						
TP9	RINSE	N/A	12/04/18	Water	Gross Beta -0.8 pCi/L						
TP17	ROAD	0 - 0.5	12/06/18	Soil	8.7	0.0027	8.2	11	27	0.054	20
TP17	ROAD	2 - 2.5	12/06/18	Soil	1.64	0.000062	2	3.9	13	0.047	21
TP17	RINSE	N/A	12/06/18	Water	Gross Alpha 1.6 pCi/L						
TP17	RINSE	N/A	12/06/18	Water	Gross Beta 0 pCi/L						
TP22	AUM 458	0 - 0.5	12/05/18	Soil	2.69	0.065	2.1	2.7	0.2	0.054	13
TP22	AUM 458	1 - 1.5	12/05/18	Soil	4.14	0.082	2.4	3.9	0.37	0.17	8.4
TP1	MRD	0.5 - 1	12/05/18	Soil	31.6	0.081	1.3	45	8	0.054	16
TP1	MRD	1.5 - 2	12/05/18	Soil	71.8	0.33	1.7	180	0.84	0.35	21

Table 5-9 Summary of Soil Sample Results (Continued)

TEST PIT/Sample ID	Location	Depth	Sample Date	Sample Type	Constituent						
					Ra-226 pCi/g	Mercury (mg/kg)	Arsenic (mg/kg)	Uranium (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Vanadium (mg/kg)
TP1	MRD	2.5 - 3	12/05/18	Soil	3.94	0.002	0.92	21	1.5	0.052	49
TP1	MRD	N/A	12/05/18	Water	Gross Alpha 0.9 pCi/L						
TP1	MRD	N/A	12/05/18	Water	Gross Beta 0.7 pCi/L						
BLANK	NULL	N/A	12/03/18	Water	Gross Alpha 1.2 pCi/L						
BLANK	NULL	N/A	12/03/18	Water	Gross Beta -0.7 pCi/L						

Notes:

AUM = Abandoned Uranium Mine, Drain = EPA Defined Drainage, BGS = Background Sample, RINSE = Sample Rinsate, BLANK = Sample Blank, LCR = Little Colorado River, MRD = Mine Related Disturbance, DUP = Sample Duplicate

Table 5-10 ANOVA Table for Ordinary Least Square (OLS) Regression of Net Shielded Gamma on Ra-226 for the Complete Correlation Data Set (n=43)

	Estimate	Std. Error	t-value	P_r (>|t|)
Intercept	-1.33	2.73	-0.49	0.628
Net Shielded Gamma (counts per 60 sec)	0.00359	0.000354	10.143	9.65×10^{-13}

Residual standard error: 3244 on 41 degrees of freedom
Multiple r-squared: 0.715 Adjusted r-squared: 0.7081
F-statistic: 102.9 on 1 and 41 DF p-value: 9.651×10^{-13}

Table 5-11 Outlying Data Points Excluded From the Second OLS Regression

Test Pit ID	Depth Interval (inches)	Sample ID	Date Collected	Time Collected	Ra-226 Result (pCi/g)	Net Gamma[1] (counts per 60 sec)
TP-1	18-24	MRD-TP1-1.5-2.0-120518	12/5/2018	08:41	71.8	30360
TP-19	6-12	458-TP19-0.5-1.0-120518	12/5/2018	15:09	126	15102

[1] Shielded static 60-second count with a Ludlum 44-10/2221

Table 5-12 ANOVA Table for OLS Regression of Net Shielded Gamma on Ra-226 for the Second Correlation Data Set (n=41)

	Estimate	Std. Error	t-value	P_r (>|t|)
Intercept	-3.02	1.15	-2.62	0.0125
Net Shielded Gamma (counts per 60 sec)	0.00378	0.000196	19.331	$< 2.2 \times 10^{-16}$

Residual standard error: 1334 on 39 degrees of freedom
Multiple r-squared: 0.9055 Adjusted r-squared: 0.9031
F-statistic: 373.7 on 1 and 39 DF p-value: $< 2.2 \times 10^{-16}$

Table 5-13 ANOVA Table for OLS Regression of Ra-226 on Arsenic Soil Concentrations for the Second Correlation Data Set (n=41)

	Estimate	Std. Error	t-value	P_r (>|t|)
Intercept	5.26	3.09	1.70	0.0964
Arsenic	0.000905	0.000265	3.41	0.00149

Residual standard error: 15.05 on 40 degrees of freedom
Multiple r-squared: 0.226 Adjusted r-squared: 0.206
F-statistic: 11.65 on 1 and 40 DF p-value: 0.00149

Table 5-14 ANOVA Table for OLS Regression of Ra-226 on Mercury Soil Concentrations for the Second Correlation Data Set (n=41)

	Estimate	Std. Error	t-value	P_r (>|t|)
Intercept	6.17	3.60	1.72	0.0978
Mercury	176	39.8	4.42	0.000145

Residual standard error: 14.5 on 27 degrees of freedom
Multiple r-squared: 0.420 Adjusted r-squared: 0.398
F-statistic: 19.5 on 1 and 27 DF p-value: 0.000148

Table 5-15 ANOVA Table for OLS Regression of Ra-226 on Molybdenum Soil Concentrations for the Second Correlation Data Set (n=41)

	Estimate	Std. Error	t-value	P_r (>|t|)
Intercept	5.84	2.03	2.88	0.0063
Molybdenum	0.203	0.0299	6.80	3.62×10^{-8}

Residual standard error: 11.65 on 40 degrees of freedom
Multiple r-squared: 0.536 Adjusted r-squared: 0.524
F-statistic: 46.2 on 1 and 40 DF p-value: 3.62×10^{-8}

Table 5-16 ANOVA Table for OLS Regression of Ra-226 on Selenium Soil Concentrations for the Second Correlation Data Set (n=41)

	Estimate	Std. Error	t-value	P_r (>|t|)
Intercept	10.6	7.45	1.43	0.171
Selenium	26.5	23.3	1.14	0.271

Residual standard error: 19.8 on 17 degrees of freedom
Multiple r-squared: 0.0709 Adjusted r-squared: 0.0162
F-statistic: 1.30 on 1 and 17 DF p-value: 0.271

Table 5-17 ANOVA Table for OLS Regression of Ra-226 on Uranium Soil Concentrations for the Second Correlation Data Set (n=41)

	Estimate	Std. Error	t-value	P_r (>|t|)
Intercept	2.70	1.78	1.52	0.136
Uranium	7.23×10^{-4}	7.64×10^{-5}	9.46	9.41×10^{-12}

Residual standard error: 9.51 on 40 degrees of freedom
Multiple r-squared: 0.691 Adjusted r-squared: 0.683
F-statistic: 89.4 on 1 and 40 DF p-value 9.41×10^{-12}

Table 5-18 ANOVA Table for OLS Regression of Ra-226 on Vanadium Soil Concentrations for the Second Correlation Data Set (n=41)

	Estimate	Std. Error	t-value	P_r (>|t|)
Intercept	20.0	5.84	3.43	0.00141
Vanadium	-0.373	0.250	-1.49	0.144

Residual standard error: 16.6 on 40 degrees of freedom
Multiple r-squared: 0.0527 Adjusted r-squared: 0.0290
F-statistic: 2.23 on 1 and 40 DF p-value: 0.144

Table 5-19 Summary Statistics for Metals and Radiological Constituents in the Correlation Data Set

Constituent	Unit	n[1]	Minimum	Maximum	Mean	Median	Standard Deviation	Number of non-detects
Arsenic	mg/kg	41	0.92	55	8.62	3.5	11.27	0
Mercury	mg/kg	41	0.000058	0.54	0.06	0.018	0.11	13
Molybdenum	mg/kg	41	0.2	820	48.6	10	133.1	0
Ra-226	pCi/g	41	1.2	126	16.1	10	25.3	0
Selenium	mg/kg	41	0.047	0.74	0.16	0.059	0.17	23
Uranium	mg/kg	41	1.3	180	19.83	6.75	36.55	0
Vanadium	mg/kg	41	4	49	20.8	20.5	10.2	0

mg/kg = milligrams per kilogram
pCi/g = picocuries per gram

[1] The correlation population excludes two outliers and U-flagged data, if any.

Table 5-20 Adjusted r^2 Values for Regression of Ra-226 on Metals and Net Shielded Static Gamma Count Rate

Independent Variable	Dependent Variable	n	Adjusted r^2
Ra-226	Arsenic	42	0.21
Ra-226	Mercury	29	0.40
Ra-226	Molybdenum	42	0.52
Ra-226	Selenium	19	0.016
Ra-226	Uranium	43	0.68
Ra-226	Vanadium	42	0.029
Net shielded static gamma count rate	Ra-226	43	0.71
Net shielded static gamma count rate	Ra-226	41	0.90

Table 5-21 Result (p-value) of the DSC Test on Ra-226 Soil Concentrations within each BSA

Background Study Area	Alluvial #1	Alluvial #2	Drainage #2	Little Colorado River	Qter BRA	Terrace #1
Alluvial #2	1.00	-	-	-	-	-
Drainage #2	0.065	0.011	-	-	-	-
Little Colorado River	0.0089	0.00037	0.073	-	-	-

Table 5-21 Result (p-value) of the DSC Test on Ra-226 Soil Concentrations within each BSA (Continued)

Background Study Area	Alluvial #1	Alluvial #2	Drainage #2	Little Colorado River	Qter BRA	Terrace #1
Qter BRA	0.51	0.14	0.038	0.0021	-	-
Terrace #1	0.64	0.30	0.038	0.0021	1.00	-
Terrace #2	0.99	1.00	0.020	0.0021	0.13	0.49

Table 5-22 Investigation Levels for Each of the Pooled BSAs

Pooled BSA	95% Gamma UTL (cpm)	IL (cpm)
Alluvial BSA #1 and # 2, Terrace BSA #1 and #2, EPA "Qter BRA"	48,212	51,824
Drainage BSA # 2	43,564	47,176
Little Colorado River BSA	26,053	29,665

cpm = counts per minute
IL is calculated as 3,612 cpm (equivalent to 1.24 pCi/g, as described in Section 5.4) plus the 95% gamma UTL.

Table 6-1 Summary of HHSRE Soil Exposure Point Concentrations by Evaluated Area

Evaluated Area	PCOCs	Units	Freq of Detection	Mean or KM Mean	Distribution Type	Recommended UCL95 of the Mean	Comment
APE with AUMs (Dry Scenario)	Arsenic	mg/kg	62/62	4.66	No discernible	7.65	
	Mercury	mg/kg	56/62	0.0168	No discernible	0.0353	
	Molybdenum	mg/kg	45/62	11.4	No discernible	36.7	
	Ra-226	pCi/g	62/62	5.18	No discernible	10.9	
	Selenium	mg/kg	25/62	0.231	Gamma	0.316	[a]
	Uranium	mg/kg	62/62	6.89	No discernible	15.8	
	Vanadium	mg/kg	62/62	42.3	No discernible	57.2	
APE with AUMs (Wet Scenario)	Arsenic	mg/kg	50/50	5.30	No discernible	8.91	
	Mercury	mg/kg	45/50	0.020	No discernible	0.0426	
	Molybdenum	mg/kg	43/50	14.1	No discernible	58.7	
	Ra-226	pCi/g	50/50	6.21	No discernible	13.2	
	Selenium	mg/kg	25/50	0.272	Gamma	0.373	
	Uranium	mg/kg	50/50	8.38	No discernible	19.3	
	Vanadium	mg/kg	50/50	49.0	No discernible	64.9	
APE Less AUMs (Dry Scenario)	Arsenic	mg/kg	45/45	3.00	No discernible	3.41	[b]
	Mercury	mg/kg	42/45	0.00773	No discernible	0.0141	
	Molybdenum	mg/kg	28/45	1.58	No discernible	5.43	
	Ra-226	pCi/g	45/45	2.48	Gamma	2.93	
	Selenium	mg/kg	18/45	0.253	Approximate Gamma	0.38	[a]
	Uranium	mg/kg	45/45	2.74	No discernible	4.33	
	Vanadium	mg/kg	45/45	48.23	No discernible	66.9	

Table 6-1 Summary of HHSRE Soil Exposure Point Concentrations by Evaluated Area (Continued)

Evaluated Area	PCOCs	Units	Freq of Detection	Mean or KM Mean	Distribution Type	Recommended UCL 95 of the Mean	Comment
APE Less AUMs (Wet Scenario)	Arsenic	mg/kg	33/33	3.37	No discernible	3.89	
	Mercury	mg/kg	31/33	0.00937	No discernible	0.0177	
	Molybdenum	mg/kg	26/33	2.066	No discernible	7.27	
	Ra-226	pCi/g	33/33	3.054	No discernible	3.56	
	Selenium	mg/kg	18/33	0.326	Approximate Gamma	0.510	
	Uranium	mg/kg	33/33	3.47	No discernible	4.24	
	Vanadium	mg/kg	33/33	60.6	No discernible	78.2	
Outside of APE (Wet and Dry Scenario)	Arsenic	mg/kg	41/41	2.97	Normal	3.23	
	Mercury	mg/kg	40/41	0.0103	Normal	0.0116	
	Molybdenum	mg/kg	24/41	0.254	Gamma	0.338	[a]
	Ra-226	pCi/g	41/41	1.988	Approximate Normal	2.141	
	Selenium	mg/kg	11/41	0.173	Normal	0.231	
	Uranium	mg/kg	41/41	2.54	Lognormal	2.92	
	Vanadium	mg/kg	41/41	43.23	Normal	48.17	
AUM 457 (Wet and Dry Scenario)	Arsenic	mg/kg	11/11	4.45	Approximate Lognormal	6.57	
	Mercury	mg/kg	8/11	0.0118	Normal	0.0171	
	Molybdenum	mg/kg	11/11	10.4	Gamma	24.39	
	Ra-226	pCi/g	11/11	7.67	Gamma	15.75	
	Selenium	mg/kg	4/12	0.115	Normal	0.168	
	Uranium	mg/kg	11/11	6.46	Gamma	9.74	
	Vanadium	mg/kg	11/11	33.6	Normal	38.18	

Table 6-1 Summary of HHSRE Soil Exposure Point Concentrations by Evaluated Area (Continued)

Evaluated Area	PCOCs	Units	Freq of Detection	Mean or KM Mean	Distribution Type	Recommended UCL 95 of the Mean	Comment
AUM 458 (Dry Scenario Only)	Arsenic	mg/kg	5/5	19.5	Normal	27.7	
	Mercury	mg/kg	5/5	0.11	Normal	0.17	
	Molybdenum	mg/kg	5/5	95.8	Gamma	350	[c]
	Ra-226	pCi/g	5/5	22.05	Approximate Lognormal	73.9	[c]
	Selenium	mg/kg	3/5	0.267	Normal	0.518	
	Uranium	mg/kg	5/5	44.9	Normal	86.2	
	Vanadium	mg/kg	5/5	15	No discernible	17	[c]
AUM 459 (Dry Scenario Only)	Arsenic	mg/kg	1/1	7.25	-	7.25	[d]
	Mercury	mg/kg	1/1	0.01295	-	0.01295	[d]
	Molybdenum	mg/kg	1/1	45	-	45	[d]
	Ra-226	pCi/g	1/1	14.95	-	14.95	[d]
	Selenium	mg/kg	0/1	ND	-	ND	
	Uranium	mg/kg	1/1	9.00	-	9.00	[d]
	Vanadium	mg/kg	1/1	6.1	-	6.1	[d]

Table 6-1 Summary of HHSRE Soil Exposure Point Concentrations by Evaluated Area (Continued)

Evaluated Area	PCOCs	Units	Freq of Detection	Mean or KM Mean	Distribution Type	Recommended UCL 95 of the Mean	Comment
LCR Channel Area (Dry Scenario Only)	Arsenic	mg/kg	12/12	1.96	Normal	2.12	
	Mercury	mg/kg	11/12	0.00322	Normal	0.00397	
	Molybdenum	mg/kg	2/12	0.23	No discernible	0.490	
	Ra-226	pCi/g	12/12	0.915	Normal	1.05	
	Selenium	mg/kg	0/12	ND	-	-	
	Uranium	mg/kg	12/12	0.725	No discernible	0.921	[a]
	Vanadium	mg/kg	12/12	14.2	Approximate Gamma	16.5	

Notes:

Arsenic and uranium were reported by the laboratory with unit of µg/kg but were converted to unit of mg/kg (by dividing by 1,000) in this table and for all risk calculations.

When detection frequency is 100% the arithmetic mean is reported, otherwise the mean calculated using the Kaplan-Meier method is reported.

All calculations performed using EPA software ProUCL (v 5.1) (EPA, 2016c). Additional summary information and the associated ProUCL output are provided in Appendix Table F2-2 and F2-3 of the Phase III Summary Report (Appendix M).

ND = not detected

UCL = upper confidence limit

[a] Two UCLs were suggested by ProUCL and the larger of the two was reported here and used for risk calculations.

[b] Three UCLs were suggested by ProUCL and the larger of the three was reported here and used for risk calculations.

[c] Recommended UCL exceeded the maximum detection. Latter was used as the UCL value.

[d] No output from ProUCL because single sample collected from this area. Used detected result as mean and UCL value.

Table 6-2 HHSRE Evaluation Areas and Assigned EPA Risk Calculator Area Correction Factors

HHSRE Evaluation Areas	Scenario	Estimated Area (m^2)	Equivalent Area (acres)	Assigned Areas for EPA Risk Calculator (acres)
APE Area with AUMs [a]	Dry	2,027,027	501	250[b]
	Wet	1,750,663	433	250[b]
APE Area Less AUMs [a]	Dry	1,702,713	421	250[b]
	Wet	1,426,349	352	250[b]
Outside of APE	Dry	1,948,320	481	250[b]
	Wet	1,948,320	481	250[b]
AUM 457	Dry	102,531	25.3	25
	Wet	99,570	24.6	25
AUM 458	Dry	58,269	14.4	25
AUM 459[a]	Dry	82,298	20.3	25
LCR Channel Area	Dry	58,869	14.5	25

Notes:

Estimated areas were calculated using ArcGIS from Figure 2-1 – Site Location and Proposed Area of Potential Effect.

The non-rad PRG uses acres in calculation of Particulate Emission Factor (Wind Driven) and similar terms such as volatilization rates (which is relevant to the assessment of mercury). The rad PRG uses areas in both m^2 and also in acres, depending on the parameter. Areas (in m^2) are used for rad PRG Equations and Parameters (e.g., gamma emission calculations) but areas (in acres) are used to calculate particulate emissions. For consistency, areas in acres were used for all calculations.

[a] Only includes portion of AUM 459 that falls inside of APE (1,357 m^2)

[b] The maximum acreage for the non-rad and rad-PRG calculator is 250 acres (equivalent to approximately 1,000,000 m^2).

Table 6-3 Summary of Grain Size Analyses of Soils

		Sample ID and Description of Sampling Location			
		TP2-0.0-0.5	**TP6-0.5-1.01**	**TP16-0.5-1.01**	**TP18-0.0-0.5**
General Group	**Parameter**	**Native Alluvium (northern end of the Site)**	**Upgrader Discharge Material**	**Typical Property Drainage**	**TENORM at AUM 457**
%Gravel	%Coarse Gravel	0	0	0	0
	%Fine Gravel	0.1	1.1	0.4	8.6
%Sand	%Coarse Sand	0.2	0.6	1.0	2.4
	%Medium Sand	15.5	21.7	28.3	18.0
	%Fine Sand	70.6	57.9	51.3	44.0
%Fines	%Clay	1.8	0	0	1.4
	%Silt	11.8	18.7	19.0	25.6
Description		**Fine sand**	**Fine sand**	**Fine sand**	**Fine sand**

Table 6-4a Non-cancer HQ Results and Cancer Risk Results for Individual Non-Radiological and Radiological PCOCs – On-Site Workers

Evaluated Area	PCOCs	Units	Soil EPC Values		Hazard Quotient		Carcinogenic Risk	
			UCL	Mean	UCL	Mean	UCL	Mean
APE with AUMs (Dry Scenario)	Arsenic	mg/kg	7.65E+00	4.66E+00	1E-06	8E-07	3E-10	2E-10
	Mercury	mg/kg	3.53E-02	1.68E-02	3E-08	1E-08	--	--
	Molybdenum	mg/kg	3.67E+01	1.14E+01	5E-07	2E-07	--	--
	Ra-226	pCi/g	1.09E+01	5.18E+00	--	--	6E-08	3E-08
	Selenium	mg/kg	3.16E-01	2.31E-01	5E-09	3E-09	--	--
	Uranium	mg/kg	1.58E+01	6.89E+00	6E-06	2E-06	--	--
	Vanadium	mg/kg	5.72E+01	4.23E+01	8E-07	6E-07	--	--
APE Area with AUMs (Wet Scenario)	Arsenic	mg/kg	8.91E+00	5.30E+00	2E-06	9E-07	3E-10	2E-10
	Mercury	mg/kg	4.26E-02	2.00E-02	3E-08	2E-08	--	--
	Molybdenum	mg/kg	5.87E+01	1.41E+01	8E-07	2E-07	--	--
	Ra-226	pCi/g	1.32E+01	6.21E+00	--	--	8E-08	4E-08
	Selenium	mg/kg	3.73E-01	2.72E-01	5E-09	4E-09	--	--
	Uranium	mg/kg	1.93E+01	8.38E+00	7E-06	3E-06	--	--
	Vanadium	mg/kg	6.49E+01	4.90E+01	9E-07	7E-07	--	--
APE Less AUMs (Dry Scenario)	Arsenic	mg/kg	3.41E+00	3.00E+00	6E-07	5E-07	1E-10	1E-10
	Mercury	mg/kg	1.41E-02	7.73E-03	1E-08	6E-09	--	--
	Molybdenum	mg/kg	5.43E+00	1.58E+00	8E-08	2E-08	--	--
	Ra-226	pCi/g	2.93E+00	2.48E+00	--	--	2E-08	1E-08
	Selenium	mg/kg	3.77E-01	2.53E-01	5E-09	4E-09	--	--
	Uranium	mg/kg	4.33E+00	2.74E+00	2E-06	1E-06	--	--
	Vanadium	mg/kg	6.69E+01	4.82E+01	1E-06	7E-07	--	--

Table 6-4a Non-cancer HQ Results and Cancer Risk Results for Individual Non-Radiological and Radiological PCOCs – On-Site Workers (Continued)

Evaluated Area	PCOCs	Units	Soil EPC Values		Hazard Quotient		Carcinogenic Risk	
			UCL	Mean	UCL	Mean	UCL	Mean
APE Less AUMs (Wet Scenario)	Arsenic	mg/kg	3.89E+00	3.37E+00	7E-07	6E-07	2E-10	1E-10
	Mercury	mg/kg	1.77E-02	9.37E-03	1E-08	7E-09	--	--
	Molybdenum	mg/kg	7.27E+00	2.07E+00	1E-07	3E-08	--	--
	Ra-226	pCi/g	3.56E+00	3.05E+00	--	--	2E-08	2E-08
	Selenium	mg/kg	5.10E-01	3.26E-01	7E-09	5E-09	--	--
	Uranium	mg/kg	4.24E+00	3.47E+00	2E-06	1E-06	--	--
	Vanadium	mg/kg	7.82E+01	6.06E+01	1E-06	9E-07	--	--
Outside of APE (Wet and Dry Scenario)	Arsenic	mg/kg	3.23E+00	2.97E+00	6E-07	5E-07	1E-10	1E-10
	Mercury	mg/kg	1.16E-02	1.03E-02	9E-09	8E-09	--	--
	Molybdenum	mg/kg	3.38E-01	2.54E-01	5E-09	4E-09	--	--
	Ra-226	pCi/g	2.14E+00	1.99E+00	--	--	1E-08	1E-08
	Selenium	mg/kg	2.31E-01	1.73E-01	3E-09	2E-09	--	--
	Uranium	mg/kg	2.92E+00	2.54E+00	1E-06	9E-07	--	--
	Vanadium	mg/kg	4.82E+01	4.32E+01	7E-07	6E-07	--	--
AUM 457 (Wet and Dry Scenario)	Arsenic	mg/kg	6.57E+00	4.45E+00	1E-06	8E-07	3E-10	2E-10
	Mercury	mg/kg	1.71E-02	1.18E-02	9E-09	6E-09	--	--
	Molybdenum	mg/kg	2.44E+01	1.04E+01	4E-07	1E-07	--	--
	Ra-226	pCi/g	1.58E+01	7.67E+00	--	--	9E-08	4E-08
	Selenium	mg/kg	1.68E-01	1.15E-01	2E-09	2E-09	--	--
	Uranium	mg/kg	9.74E+00	6.46E+00	4E-06	2E-06	--	--
	Vanadium	mg/kg	3.82E+01	3.36E+01	5E-07	5E-07	--	--

Table 6-4a Non-cancer HQ Results and Cancer Risk Results for Individual Non-Radiological and Radiological PCOCs – On-Site Workers (Continued)

Evaluated Area	PCOCs	Units	Soil EPC Values		Hazard Quotient		Carcinogenic Risk	
			UCL	Mean	UCL	Mean	UCL	Mean
AUM 458 (Dry Scenario Only)	Arsenic	mg/kg	2.77E+01	1.95E+01	5E-06	3E-06	1E-09	8E-10
	Mercury	mg/kg	1.70E-01	1.10E-01	9E-08	6E-08	-	-
	Molybdenum	mg/kg	3.50E+02	9.58E+01	5E-06	1E-06	-	-
	Ra-226	pCi/g	7.39E+01	2.21E+01	-	--	4E-07	1E-07
	Selenium	mg/kg	5.18E-01	2.67E-01	7E-09	4E-09	-	-
	Uranium	mg/kg	8.62E+01	4.49E+01	3E-05	2E-05	-	-
	Vanadium	mg/kg	1.76E+01	1.50E+01	3E-07	2E-07	-	-
AUM 459 (Dry Scenario Only)	Arsenic	mg/kg	7.25E+00	7.25E+00	1E-06	1E-06	3E-10	3E-10
	Mercury	mg/kg	1.30E-02	1.30E-02	7E-09	7E-09	-	-
	Molybdenum	mg/kg	4.50E+01	4.50E+01	6E-07	6E-07	-	-
	Ra-226	pCi/g	1.50E+01	1.50E+01	-	-	9E-08	9E-08
	Selenium	mg/kg	ND	ND	-	-	-	-
	Uranium	mg/kg	9.00E+00	9.00E+00	3E-06	3E-06	-	-
	Vanadium	mg/kg	6.10E+00	6.10E+00	9E-08	9E-08	-	-
LCR Channel Area (Dry Scenario Only)	Arsenic	mg/kg	2.12E+00	1.96E+00	4E-07	3E-07	8E-11	8E-11
	Mercury	mg/kg	3.97E-03	3.22E-03	2E-09	2E-09	-	-
	Molybdenum	mg/kg	4.90E-01	2.30E-01	7E-09	3E-09	-	-
	Ra-226	pCi/g	1.05E+00	9.15E-01	-	-	6E-09	5E-09
	Selenium	mg/kg	ND	ND	-	-	-	-
	Uranium	mg/kg	9.21E-01	7.25E-01	3E-07	3E-07	-	-
	Vanadium	mg/kg	1.65E+01	1.42E+01	2E-07	2E-07	-	-

Notes: Arsenic and uranium were reported by the laboratory with unit of µg/kg but were converted to unit of mg/kg (by dividing by 1,000) in this table and for all risk calculations Supporting calculations provided in Appendix F of the Phase III Summary Report (Appendix M).
A dash indicates calculation was not required.
Hazard Quotient (HQ) values less than one are below levels of regulatory concern.
Cancer risk values below or within EPA acceptable range of 1E-6 and 1E-4 are not of regulatory concern.

Table 6-4b Non-cancer HI Results and Sum Cancer Risk Results for Non-Radiological and Radiological PCOCs – On-Site Workers

Evaluated Area	Hazard Index			Sum Cancer Risk	
	UCL	Mean		UCL	Mean
APE with AUMs (Dry Scenario)	8E-06	4E-06		6E-08	3E-08
APE with AUMs (Wet Scenario)	1E-05	5E-06		8E-08	4E-08
APE Less AUMs (Dry Scenario)	3E-06	2E-06		2E-08	1E-08
APE Less AUMs (Wet Scenario)	3E-06	3E-06		2E-08	2E-08
Outside of APE (Wet and Dry Scenario)	2E-06	2E-06		1E-08	1E-08
AUM 457 (Wet and Dry Scenario)	6E-06	4E-06		9E-08	4E-08
AUM 458 (Wet and Dry Scenario)	4E-05	2E-05		4E-08	1E-07
AUM 459 (Wet and Dry Scenario)	5E-06	5E-06		9E-08	9E-08
LCR Channel Area (Dry Scenario Only)	9E-07	8E-07		6E-09	5E-09

Notes:
Hazard Index (HI) is sum of individual PCOC HQ values.
HI values less than one indicate are below regulatory concern.
Sum of cancer risk values below or within EPA acceptable range of 1E-6 and 1E-4 are not of regulatory concern.

Table 6-5a Non-cancer HQ Results and Cancer Risk Results for Individual Non-Radiological and Radiological PCOCs – Adult Recreator Based on 24 Years of Exposure

Evaluated Area	PCOCs	Units	Soil EPC Values		Hazard Quotient		Carcinogenic Risk	
			UCL	Mean	UCL	Mean	UCL	Mean
APE with AUMs (Dry Scenario)	Arsenic	mg/kg	7.65E+00	4.66E+00	9.E-04	5.E-04	1.E-07	8.E-08
	Mercury	mg/kg	3.53E-02	1.68E-02	5.E-05	3.E-05	--	--
	Molybdenum	mg/kg	3.67E+01	1.14E+01	4.E-04	1.E-04	--	--
	Ra-226	pCi/g	1.09E+01	5.18E+00	--	--	9E-05	4E-05
	Selenium	mg/kg	3.16E-01	2.31E-01	3.E-06	2.E-06	--	--
	Uranium	mg/kg	1.58E+01	6.89E+00	4.E-03	2.E-03	--	--
	Vanadium	mg/kg	5.72E+01	4.23E+01	5.E-04	4.E-04	--	--
APE with AUMs (Wet Scenario)	Arsenic	mg/kg	8.91E+00	5.30E+00	1.E-03	6.E-04	2.E-07	9.E-08
	Mercury	mg/kg	4.26E-02	2.00E-02	6.E-05	3.E-05	--	--
	Molybdenum	mg/kg	5.87E+01	1.41E+01	6.E-04	1.E-04	--	--
	Ra-226	pCi/g	1.32E+01	6.21E+00	--	--	1E-04	5E-05
	Selenium	mg/kg	3.73E-01	2.72E-01	4.E-06	3.E-06	--	--
	Uranium	mg/kg	1.93E+01	8.38E+00	5.E-03	2.E-03	--	--
	Vanadium	mg/kg	6.49E+01	4.90E+01	6.E-04	5.E-04	--	--
APE Less AUMs (Dry Scenario)	Arsenic	mg/kg	3.41E+00	3.00E+00	4.E-04	3.E-04	6.E-08	5.E-08
	Mercury	mg/kg	1.41E-02	7.73E-03	2.E-05	1.E-05	--	--
	Molybdenum	mg/kg	5.43E+00	1.58E+00	5.E-05	2.E-05	--	--
	Ra-226	pCi/g	2.93E+00	2.48E+00	--	--	2E-05	2E-05
	Selenium	mg/kg	3.77E-01	2.53E-01	4.E-06	2.E-06	--	--
	Uranium	mg/kg	4.33E+00	2.74E+00	1.E-03	7.E-04	--	--
	Vanadium	mg/kg	6.69E+01	4.82E+01	6.E-04	5.E-04	--	--

Table 6-5a Non-cancer HQ Results and Cancer Risk Results for Individual Non-Radiological and Radiological PCOCs - Adult Recreator Based on 24 Years of Exposure (Continued)

Evaluated Area	PCOCs	Units	Soil EPC Values		Hazard Quotient		Carcinogenic Risk	
			UCL	Mean	UCL	Mean	UCL	Mean
APE Less AUMs (Wet Scenario)	Arsenic	mg/kg	3.89E+00	3.37E+00	5.E-04	4.E-04	7.E-08	6.E-08
	Mercury	mg/kg	1.77E-02	9.37E-03	3.E-05	1.E-05	--	--
	Molybdenum	mg/kg	7.27E+00	2.07E+00	7.E-05	2.E-05	--	--
	Ra-226	pCi/g	3.56E+00	3.05E+00	--	--	3E-05	2E-05
	Selenium	mg/kg	5.10E-01	3.26E-01	5.E-06	3.E-06	--	--
	Uranium	mg/kg	4.24E+00	3.47E+00	1.E-03	8.E-04	--	--
	Vanadium	mg/kg	7.82E+01	6.06E+01	7.E-04	6.E-04	--	--
Outside of APE (Wet and Dry Scenario)	Arsenic	mg/kg	3.23E+00	2.97E+00	4.E-04	3.E-04	6.E-08	5.E-08
	Mercury	mg/kg	1.16E-02	1.03E-02	2.E-05	2.E-05	--	--
	Molybdenum	mg/kg	3.38E-01	2.54E-01	3.E-06	2.E-06	--	--
	Ra-226	pCi/g	2.14E+00	1.99E+00	--	--	2E-05	2E-05
	Selenium	mg/kg	2.31E-01	1.73E-01	2.E-06	2.E-06	--	--
	Uranium	mg/kg	9.74E+00	6.46E+00	7.E-04	6.E-04	--	--
	Vanadium	mg/kg	4.82E+01	4.32E+01	5.E-04	4.E-04	--	--
AUM 457 (Wet and Dry Scenario)	Arsenic	ug/kg	6.57E+03	4.45E+03	8.E-04	5.E-04	1.E-07	8.E-08
	Mercury	mg/kg	1.71E-02	1.18E-02	2.E-05	1.E-05	--	--
	Molybdenum	mg/kg	2.44E+01	1.04E+01	8.E-05	3.E-05	--	--
	Ra-226	pCi/g	1.58E+01	7.67E+00	--	--	1E-04	6E-05
	Selenium	mg/kg	1.68E-01	1.15E-01	2.E-06	1.E-06	--	--
	Uranium	ug/kg	9.74E+03	6.46E+03	2.E-03	2.E-03	--	--
	Vanadium	mg/kg	3.82E+01	3.36E+01	4.E-04	3.E-04	--	--

Table 6-5a Non-cancer HQ Results and Cancer Risk Results for Individual Non-Radiological and Radiological PCOCs - Adult Recreator Based on 24 Years of Exposure (Continued)

Evaluated Area	PCOCs	Units	Soil EPC Values		Hazard Quotient		Carcinogenic Risk	
			UCL	Mean	UCL	Mean	UCL	Mean
AUM 458 (Dry Scenario Only)	Arsenic	mg/kg	2.77E+01	1.95E+01	3.E-03	2.E-03	5.E-07	3.E-07
	Mercury	mg/kg	1.70E-01	1.10E-01	2.E-04	1.E-04	-	-
	Molybdenum	mg/kg	1.03E+03	9.58E+01	3.E-03	3.E-04	-	-
	Ra-226	pCi/g	7.39E+01	2.21E+01	-	-	6E-04	2E-04
	Selenium	mg/kg	5.18E-01	2.67E-01	5.E-06	3.E-06	-	-
	Uranium	mg/kg	8.62E+01	4.49E+01	2.E-02	1.E-02	-	-
	Vanadium	mg/kg	1.76E+01	1.50E+01	2.E-04	1.E-04	-	-
AUM 459 (Dry Scenario Only)	Arsenic	mg/kg	7.25E+00	7.25E+00	8.E-04	8.E-04	1.E-07	1.E-07
	Mercury	mg/kg	1.30E-02	1.30E-02	1.E-05	1.E-05	-	-
	Molybdenum	mg/kg	4.50E+01	4.50E+01	1.E-04	1.E-04	-	-
	Ra-226	pCi/g	1.50E+01	1.50E+01	-	-	1E-04	1E-04
	Selenium	mg/kg	ND	ND	-	-	-	-
	Uranium	mg/kg	9.00E+00	9.00E+00	2.E-03	2.E-03	-	-
	Vanadium	mg/kg	6.10E+00	6.10E+00	6.E-05	6.E-05	-	-
LCR Channel Area (Dry Scenario Only)	Arsenic	mg/kg	2.12E+00	1.96E+00	2.E-04	2.E-04	4.E-08	4.E-08
	Mercury	mg/kg	3.97E-03	3.22E-03	4.E-06	4.E-06	-	-
	Molybdenum	mg/kg	4.90E-01	2.30E-01	2.E-06	8.E-07	-	-
	Ra-226	pCi/g	1.05E+00	9.15E-01	-	-	8E-06	7E-06
	Selenium	mg/kg	---	ND	-	-	-	-
	Uranium	mg/kg	9.21E-01	7.25E-01	2.E-04	2.E-04	-	-
	Vanadium	mg/kg	1.65E+01	1.42E+01	2.E-04	1.E-04	-	-

Notes: Arsenic and uranium were reported by the laboratory with unit of µg/kg but were converted to unit of mg/kg (by dividing by 1,000) in this table and for all risk calculations. Supporting calculations provided in Appendix F of the Phase III Summary Report (Appendix M).
A dash indicates calculation was not required.
Hazard Quotient (HQ) values less than one are below regulatory concern.
Cancer risk values below or within EPA acceptable range of 1E-6 and 1E-4 are not of regulatory concern.

Table 6-5b Non-cancer HI Results and Sum Cancer Risk Results for Non-Radiological and Radiological PCOCs – Adult Recreator Based on 24 Years of Exposure

Evaluated Area	Hazard Index			Sum Cancer Risk	
	UCL	Mean		UCL	Mean
APE with AUMs (Dry Scenario)	6E-03	3E-03		9E-05	4E-05
APE with AUMs (Wet Scenario)	7E-03	3E-03		1E-04	5E-05
APE Less AUMs (Dry Scenario Only)	2E-03	1E-03		2E-05	2E-05
APE Less AUMs (Wet Scenario)	2E-03	2E-03		3E-05	2E-05
Outside of APE (Wet and Dry Scenario)	2E-03	1E-03		2E-05	2E-05
AUM 457 (Wet and Dry Scenario)	4E-03	2E-03		1E-04	6E-05
AUM 458 (Wet and Dry Scenario)	3E-02	1E-02		6E-04	2E-04
AUM 459 (Wet and Dry Scenario)	3E-03	3E-03		1E-04	1E-04
LCR Channel Area (Dry Scenario Only)	6E-04	5E-04		8E-06	7E-06

Notes:

Hazard Index (HI) is sum of individual PCOC HQ values.

HI values less than one are below regulatory concern.

Sum of cancer risk values below or within EPA acceptable range of 1E-6 and 1E-4 are not of regulatory concern.

Table 6-6a Non-cancer HQ Results and Cancer Risk Results for Individual Non-Radiological and Radiological PCOCs – Child Recreator

Evaluated Area	PCOCs	Units	Soil EPC Values		Hazard Quotient		Carcinogenic Risk	
			UCL	Mean	UCL	Mean	UCL	Mean
APE with AUMs (Dry Scenario)	Arsenic	mg/kg	7.65E+00	4.66E+00	9E-03	5E-03	1E-07	7E-08
	Mercury	mg/kg	3.53E-02	1.68E-02	5E-05	3E-05	-	-
	Molybdenum	mg/kg	3.67E+01	1.14E+01	4E-03	1E-03	-	-
	Ra-226	pCi/g	1.09E+01	5.18E+00	-	-	7E-06	4E-06
	Selenium	mg/kg	3.16E-01	2.31E-01	3E-05	2E-05	-	-
	Uranium	mg/kg	1.58E+01	6.89E+00	4E-02	2E-02	-	-
	Vanadium	mg/kg	5.72E+01	4.23E+01	6E-03	4E-03	-	-
APE with AUMs (Wet Scenario)	Arsenic	mg/kg	8.91E+00	5.30E+00	1E-02	6E-03	1E-07	8E-08
	Mercury	mg/kg	4.26E-02	2.00E-02	6E-05	3E-05	-	-
	Molybdenum	mg/kg	5.87E+01	1.41E+01	6E-03	1E-03	-	-
	Ra-226	pCi/g	1.32E+01	6.21E+00	-	-	9E-06	4E-06
	Selenium	mg/kg	3.73E-01	2.72E-01	4E-05	3E-05	-	-
	Uranium	mg/kg	1.93E+01	8.38E+00	5E-02	2E-02	-	-
	Vanadium	mg/kg	6.49E+01	4.90E+01	7E-03	5E-03	-	-
APE Less AUMs (Dry Scenario)	Arsenic	mg/kg	3.41E+00	3.00E+00	4E-03	3E-03	5E-08	4E-08
	Mercury	mg/kg	1.41E-02	7.73E-03	2E-05	1E-05	-	-
	Molybdenum	mg/kg	5.43E+00	1.58E+00	6E-04	2E-04	-	-
	Ra-226	pCi/g	2.93E+00	2.48E+00	-	-	2E-06	2E-06
	Selenium	mg/kg	3.77E-01	2.53E-01	4E-05	3E-05	-	-
	Uranium	mg/kg	4.33E+00	2.74E+00	1E-02	7E-03	-	-
	Vanadium	mg/kg	6.69E+01	4.82E+01	7E-03	5E-03	-	-

Table 6-6a Non-cancer HQ Results and Cancer Risk Results for Individual Non-Radiological and Radiological PCOCs - Child Recreator (Continued)

Evaluated Area	PCOCs	Units	Soil EPC Values		Hazard Quotient		Carcinogenic Risk	
			UCL	Mean	UCL	Mean	UCL	Mean
APE Less AUMs (Wet Scenario)	Arsenic	mg/kg	3.89E+00	3.37E+00	4E-03	4E-03	6E-08	5E-08
	Mercury	mg/kg	1.77E-02	9.37E-03	3E-05	1E-05	-	-
	Molybdenum	mg/kg	7.27E+00	2.07E+00	7E-04	2E-04	-	-
	Ra-226	pCi/g	3.56E+00	3.05E+00	-	-	2E-06	2E-06
	Selenium	mg/kg	5.10E-01	3.26E-01	5E-05	3E-05	-	-
	Uranium	mg/kg	4.24E+00	3.47E+00	1E-02	9E-03	-	-
	Vanadium	mg/kg	7.82E+01	6.06E+01	8E-03	6E-03	-	-
Outside of APE (Wet and Dry Scenario)	Arsenic	mg/kg	3.23E+00	2.97E+00	4E-03	3E-03	5E-08	4E-08
	Mercury	mg/kg	1.16E-02	1.03E-02	2E-05	2E-05	-	-
	Molybdenum	mg/kg	3.38E-01	2.54E-01	3E-05	3E-05	-	-
	Ra-226	pCi/g	2.14E+00	1.99E+00	-	-	1E-06	1E-06
	Selenium	mg/kg	2.31E-01	1.73E-01	2E-05	2E-05	-	-
	Uranium	mg/kg	2.92E+00	2.54E+00	7E-03	6E-03	-	-
	Vanadium	mg/kg	4.82E+01	4.32E+01	5E-03	4E-03	-	-

Table 6-6a Non-cancer HQ Results and Cancer Risk Results for Individual Non-Radiological and Radiological PCOCs - Child Recreator (Continued)

Evaluated Area	PCOCs	Units	Soil EPC Values		Hazard Quotient Evaluated Area		Carcinogenic Risk Units	
			UCL	Mean	UCL	Mean	UCL	Mean
AUM 457 (Wet and Dry Scenario)	Arsenic	mg/kg	6.57E+00	4.45E+00	8E-03	5E-03	1E-07	7E-08
	Mercury	mg/kg	1.71E-02	1.18E-02	2E-05	1E-05	-	-
	Molybdenum	mg/kg	2.44E+01	1.04E+01	2E-03	1E-03	-	-
	Ra-226	pCi/g	1.58E+01	7.67E+00	-	-	1E-05	5E-06
	Selenium	mg/kg	1.68E-01	1.15E-01	2E-05	1E-05	-	-
	Uranium	mg/kg	9.74E+00	6.46E+00	2E-02	2E-02	-	-
	Vanadium	mg/kg	3.82E+01	3.36E+01	4E-03	3E-03	-	-
AUM 458 (Dry Scenario Only)	Arsenic	mg/kg	2.77E+01	1.95E+01	3E-02	2E-02	4E-07	3E-07
	Mercury	mg/kg	1.70E-01	1.10E-01	2E-04	1E-04	-	-
	Molybdenum	mg/kg	3.50E+02	9.58E+01	4E-02	1E-02	-	-
	Ra-226	pCi/g	7.39E+01	2.21E+01	-	-	5E-05	2E-05
	Selenium	mg/kg	5.18E-01	2.67E-01	5E-05	3E-05	-	-
	Uranium	mg/kg	8.62E+01	4.49E+01	2E-01	1E-01	-	-
	Vanadium	mg/kg	1.76E+01	1.50E+01	2E-03	2E-03	-	-
AUM 459 (Dry Scenario Only)	Arsenic	mg/kg	7.25E+00	7.25E+00	8E-03	8E-03	1E-07	1E-07
	Mercury	mg/kg	1.30E-02	1.30E-02	1E-05	1E-05	-	-
	Molybdenum	mg/kg	4.50E+01	4.50E+01	5E-03	5E-03	-	-
	Ra-226	pCi/g	1.50E+01	1.50E+01	-	-	1E-06	1E-06
	Selenium	mg/kg	ND	ND	-	-	-	-
	Uranium	mg/kg	9.00E+00	9.00E+00	2E-02	2E-02	-	-
	Vanadium	mg/kg	6.10E+00	6.10E+00	6E-04	6E-04	-	-

Table 6-6a Non-cancer HQ Results and Cancer Risk Results for Individual Non-Radiological and Radiological PCOCs - Child Recreator (Continued)

Evaluated Area	PCOCs	Units	Soil EPC Values		Hazard Quotient Evaluated Area		Carcinogenic Risk Units	
LCR Channel Area (Dry Scenario Only)	Arsenic	mg/kg	2.12E+00	1.96E+00	2E-03	2E-03	3E-08	3E-08
	Mercury	mg/kg	3.97E-03	3.22E-03	4E-06	4E-06	-	-
	Molybdenum	mg/kg	4.90E-01	2.30E-01	5E-05	2E-05	-	-
	Ra-226	pCi/g	1.05E+00	9.15E-01	-	-	7E-07	6E-07
	Selenium	mg/kg	ND	ND	-	-	-	-
	Uranium	mg/kg	9.21E-01	7.25E-01	2E-03	2E-03	-	-
	Vanadium	mg/kg	1.65E+01	1.42E+01	2E-03	1E-03	-	-

Notes:

Arsenic and uranium were reported by the laboratory with unit of µg/kg but were converted to unit of mg/kg (by dividing by 1,000) in this table and for all risk calculations.

Supporting calculations provided in Appendix F of the Phase III Summary Report (provided as Appendix M to this report).

A dash indicates calculation was not required.

Hazard Quotient (HQ) values less than are below levels of regulatory concern.

Cancer risk values below or within EPA acceptable range of 1E-6 and 1E-4 are not of regulatory concern.

ND = Not detected

Table 6-6b Non-cancer HI Results and Sum Cancer Risk Results for Non-Radiological and Radiological PCOCs – Child Recreator

Evaluated Area	Hazard Index			Sum Cancer Risk	
	UCL	Mean		UCL	Mean
APE with AUMs (Dry Scenario)	6E-02	3E-02		7E-06	4E-06
APE with AUMs (Wet Scenario)	7E-02	3E-02		9E-06	4E-06
APE Less AUMs (Dry Scenario)	2E-02	2E-02		2E-06	2E-06
APE Less AUMs (Wet Scenario)	2E-02	2E-02		2E-06	2E-06
Outside of APE (Wet and Dry Scenario)	2E-02	1E-02		1E-06	1E-06
AUM 457 (Wet and Dry Scenario)	4E-02	3E-02		1E-05	5E-06
AUM 458 (Wet and Dry Scenario)	3E-01	1E-01		5E-05	1E-05
AUM 459 (Wet and Dry Scenario)	4E-02	4E-02		1E-05	1E-05
LCR Channel Area (Dry Scenario Only)	7E-03	6E-03		7E-07	6E-07

Notes:
Hazard Index (HI) is sum of individual PCOC HQ values.
HI values less than one are below levels of regulatory concern.
Sum of cancer risk values below or within EPA acceptable risk range of 1E-6 and 1E-4 are not of regulatory concern.

Table 6-7a Non-cancer HQ Results and Cancer Risk Results for Non-Radiological and Radiological PCOCs – Combined Adult and Child Recreator

Evaluated Area	PCOCs	Units	Soil EPC Values		Hazard Quotient		Carcinogenic Risk	
			UCL	Mean	UCL	Mean	UCL	Mean
APE with AUMs (Dry Scenario)	Arsenic	mg/kg	7.65E+00	4.66E+00	1E-02	6E-03	3E-07	2E-07
	Mercury	mg/kg	3.53E-02	1.68E-02	1E-04	5E-05	-	-
	Molybdenum	mg/kg	3.67E+01	1.14E+01	4E-03	1E-03	-	-
	Ra-226	pCi/g	1.09E+01	5.18E+00	-	-	9E-05	4E-05
	Selenium	mg/kg	3.16E-01	2.31E-01	4E-05	3E-05	-	-
	Uranium	mg/kg	1.58E+01	6.89E+00	4E-02	2E-02	-	-
	Vanadium	mg/kg	5.72E+01	4.23E+01	6E-03	5E-03	-	-
APE with AUMs (Wet Scenario)	Arsenic	mg/kg	8.91E+00	5.30E+00	1E-02	7E-03	3E-07	2E-07
	Mercury	mg/kg	4.26E-02	2.00E-02	1E-04	6E-05	-	-
	Molybdenum	mg/kg	5.87E+01	1.41E+01	7E-03	2E-03	-	-
	Ra-226	pCi/g	1.32E+01	6.21E+00	-	-	1E-04	5E-05
	Selenium	mg/kg	3.73E-01	2.72E-01	4E-05	3E-05	-	-
	Uranium	mg/kg	1.93E+01	8.38E+00	5E-02	2E-02	-	-
	Vanadium	mg/kg	6.49E+01	4.90E+01	7E-03	5E-03	-	-
APE Less AUMs (Dry Scenario)	Arsenic	mg/kg	3.41E+00	3.00E+00	4E-03	4E-03	1E-07	1E-07
	Mercury	mg/kg	1.41E-02	7.73E-03	4E-05	2E-05	-	-
	Molybdenum	mg/kg	5.43E+00	1.58E+00	6E-04	2E-04	-	-
	Ra-226	pCi/g	2.93E+00	2.48E+00	-	-	3E-05	2E-05
	Selenium	mg/kg	3.77E-01	2.53E-01	4E-05	3E-05	-	-
	Uranium	mg/kg	4.33E+00	2.74E+00	1E-02	8E-03	-	-
	Vanadium	mg/kg	6.69E+01	4.82E+01	7E-03	5E-03	-	-

Table 6-7a Non-cancer HQ Results and Cancer Risk Results for Non-Radiological and Radiological PCOCs – Combined Adult and Child Recreator (Continued)

Evaluated Area	PCOCs	Units	Soil EPC Values		Hazard Quotient		Carcinogenic Risk	
			UCL	Mean	UCL	Mean	UCL	Mean
APE Less AUMs (Wet Scenario)	Arsenic	mg/kg	3.89E+00	3.37E+00	5E-03	4E-03	1E-07	1E-07
	Mercury	mg/kg	1.77E-02	9.37E-03	5E-05	3E-05	-	-
	Molybdenum	mg/kg	7.27E+00	2.07E+00	8E-04	2E-04	-	-
	Ra-226	pCi/g	3.56E+00	3.05E+00	-	-	3E-05	3E-05
	Selenium	mg/kg	5.10E-01	3.26E-01	6E-05	4E-05	-	-
	Uranium	mg/kg	4.24E+00	3.47E+00	1E-02	1E-02	-	-
	Vanadium	mg/kg	7.82E+01	6.06E+01	9E-03	7E-03	-	-
Outside of APE (Wet and Dry Scenario)	Arsenic	mg/kg	3.23E+00	2.97E+00	4E-03	4E-03	1E-07	1E-07
	Mercury	mg/kg	1.16E-02	1.03E-02	3E-05	3E-05	-	-
	Molybdenum	mg/kg	3.38E-01	2.54E-01	4E-05	3E-05	-	-
	Ra-226	pCi/g	2.14E+00	1.99E+00	-	-	2E-05	2E-05
	Selenium	mg/kg	2.31E-01	1.73E-01	3E-05	2E-05	-	-
	Uranium	mg/kg	2.92E+00	2.54E+00	8E-03	7E-03	-	-
	Vanadium	mg/kg	4.82E+01	4.32E+01	5E-03	5E-03	-	-
AUM 457 (Wet and Dry Scenario)	Arsenic	mg/kg	6.57E+00	4.45E+00	8E-03	6E-03	2E-07	1E-07
	Mercury	mg/kg	1.71E-02	1.18E-02	4E-05	3E-05	-	-
	Molybdenum	mg/kg	2.44E+01	1.04E+01	3E-03	1E-03	-	-
	Ra-226	pCi/g	1.58E+01	7.67E+00	-	-	1E-04	6E-05
	Selenium	mg/kg	1.68E-01	1.15E-01	2E-05	1E-05	-	-
	Uranium	mg/kg	9.74E+00	6.46E+00	3E-02	2E-02	-	-
	Vanadium	mg/kg	3.82E+01	3.36E+01	4E-03	4E-03	-	-

Table 6-7a Non-cancer HQ Results and Cancer Risk Results for Non-Radiological and Radiological PCOCs – Combined Adult and Child Recreator (Continued)

Evaluated Area	PCOCs	Units	Soil EPC Values		Hazard Quotient		Carcinogenic Risk	
			UCL	Mean	UCL	Mean	UCL	Mean
AUM 458 (Dry Scenario Only)	Arsenic	mg/kg	2.77E+01	1.95E+01	3E-02	2E-02	9E-07	6E-07
	Mercury	mg/kg	1.70E-01	1.10E-01	4E-04	2E-04	-	-
	Molybdenum	mg/kg	3.50E+02	9.58E+01	1E-01	1E-02	-	-
	Ra-226	pCi/g	7.39E+01	2.21E+01	-	-	6E-04	2E-04
	Selenium	mg/kg	5.18E-01	2.67E-01	6E-05	3E-05	-	-
	Uranium	mg/kg	8.62E+01	4.49E+01	2E-01	1E-01	-	-
	Vanadium	mg/kg	1.76E+01	1.50E+01	2E-03	2E-03	-	-
AUM 459 (Dry Scenario Only)	Arsenic	mg/kg	7.25E+00	7.25E+00	9E-03	9E-03	2E-07	2E-07
	Mercury	mg/kg	1.30E-02	1.30E-02	3E-05	3E-05	-	-
	Molybdenum	mg/kg	4.50E+01	4.50E+01	5E-03	5E-03	-	-
	Ra-226	pCi/g	1.50E+01	1.50E+01	-	-	1E-04	1E-04
	Selenium	mg/kg	ND	ND	-	-	-	-
	Uranium	mg/kg	9.00E+00	9.00E+03	3E-02	3E-02	-	-
	Vanadium	mg/kg	6.10E+00	6.10E+00	7E-04	7E-04	-	-
LCR Channel Area (Dry Scenario Only)	Arsenic	mg/kg	2.12E+00	1.96E+00	3E-03	2E-03	7E-08	6E-08
	Mercury	mg/kg	3.97E-03	3.22E-03	9E-06	7E-06	-	-
	Molybdenum	mg/kg	4.90E-01	2.30E-01	5E-05	2E-05	-	-
	Ra-226	pCi/g	1.05E+00	9.15E-01	-	-	9E-06	8E-06
	Selenium	mg/kg	ND	ND	-	-	-	-
	Uranium	mg/kg	9.21E-01	7.25E-01	3E-03	2E-03	-	-
	Vanadium	mg/kg	1.65E+01	1.42E+01	2E-03	2E-03	-	-

Notes: Supporting calculations provided in Appendix F of the Phase III Summary Report (provided as Appendix M to this report).
A dash indicates calculation was not required.
Hazard Quotient (HQ) values less than one are below level of regulatory concern.
Cancer risk values below or within EPA acceptable range of 1E-6 and 1E-4 are not of regulatory concern.
ND = Not detected.

Table 6-7b Non-cancer HI Results and Sum Cancer Risk Results for Non-Radiological and Radiological PCOCs – Combined Adult and Child Recreator

Evaluated Area	Hazard Index			Sum Cancer Risk	
	UCL	Mean		UCL	Mean
APE with AUMs (Dry Scenario)	6E-02	3E-02		9E-05	4E-05
APE with AUMs (Wet Scenario)	8E-02	4E-02		1E-04	5E-05
APE Less AUMs (Dry Scenario)	2E-02	2E-02		3E-05	2E-05
APE Less AUMs (Wet Scenario)	3E-02	2E-02		3E-05	3E-05
Outside of APE (Wet and Dry Scenario)	2E-02	2E-02		2E-05	2E-05
AUM 457 (Wet and Dry Scenario)	4E-02	3E-02		1E-04	6E-05
AUM 458 (Wet and Dry Scenario)	4E-01	2E-01		6E-04	2E-04
AUM 459 (Wet and Dry Scenario)	4E-02	4E-02		1E-04	1E-04
LCR Channel Area (Dry Scenario Only)	7E-03	6E-03		9E-06	8E-06

Notes:

Hazard Index (HI) is sum of individual PCOC HQ values.

HI values less than one below levels of regulatory concern.

Sum of cancer risk values below or within EPA acceptable range of 1E-6 and 1E-4 are not of regulatory concern.

Table 6-8a Uncertainty Assessment - Non-cancer HQ Results and Cancer Risk Results for Individual Non-Radiological and Radiological PCOCs – Adult Recreator Based on 1 Year of Exposure

Evaluated Area	PCOCs	Units	Soil EPC Values		Hazard Quotient		Carcinogenic Risk	
			UCL	Mean	UCL	Mean	UCL	Mean
APE with AUMs (Dry Scenario)	Arsenic	mg/kg	7.65E+00	4.66E+00	9E-04	5E-04	6E-09	3E-09
	Mercury	mg/kg	3.53E-02	1.68E-02	5E-05	3E-05	-	-
	Molybdenum	mg/kg	3.67E+01	1.14E+01	4E-04	1E-04	-	-
	Ra-226	pCi/g	1.09E+01	5.18E+00	-	-	4E-06	2E-06
	Selenium	mg/kg	3.16E-01	2.31E-01	3E-06	2E-06	-	-
	Uranium	mg/kg	1.58E+01	6.89E+00	4E-03	2E-03	-	-
	Vanadium	mg/kg	5.72E+01	4.23E+01	5E-04	4E-04	-	-
APE with AUMs (Wet Scenario)	Arsenic	mg/kg	8.91E+00	5.30E+00	1E-03	6E-04	7E-09	4E-09
	Mercury	mg/kg	4.26E-02	2.00E-02	6E-05	3E-05	-	-
	Molybdenum	mg/kg	5.87E+01	1.41E+01	6E-04	1E-04	-	-
	Ra-226	pCi/g	1.32E+01	6.21E+00	-	-	4E-06	2E-06
	Selenium	mg/kg	3.73E-01	2.72E-01	4E-06	3E-06	-	-
	Uranium	mg/kg	1.93E+01	8.38E+00	5E-03	2E-03	-	-
	Vanadium	mg/kg	6.49E+01	4.90E+01	6E-04	5E-04	-	-
APE Less AUMs (Dry Scenario)	Arsenic	mg/kg	3.41E+00	3.00E+00	4E-04	3E-04	3E-09	2E-09
	Mercury	mg/kg	1.41E-02	7.73E-03	2E-05	1E-05	-	-
	Molybdenum	mg/kg	5.43E+00	1.58E+00	5E-05	2E-05	-	-
	Ra-226	pCi/g	2.93E+00	2.48E+00	-	-	1E-06	8E-07
	Selenium	mg/kg	3.77E-01	2.53E-01	4E-06	2E-06	--	--
	Uranium	mg/kg	4.33E+00	2.74E+00	1E-03	7E-04	--	--
	Vanadium	mg/kg	6.69E+01	4.82E+01	6E-04	5E-04	--	--

Table 6-8a Uncertainty Assessment - Non-cancer HQ Results and Cancer Risk Results for Individual Non-Radiological and Radiological PCOCs - Adult Recreator Based on 1 Year of Exposure (Continued)

Evaluated Area	PCOCs	Units	Soil EPC Values		Hazard Quotient		Carcinogenic Risk Units	
			UCL	Mean	UCL	Mean	UCL	Mean
APE Less AUMs (Wet Scenario)	Arsenic	mg/kg	3.89E+00	3.37E+00	5E-04	4E-04	3E-09	3E-09
	Mercury	mg/kg	1.77E-02	9.37E-03	3E-05	1E-05	-	-
	Molybdenum	mg/kg	7.27E+00	2.07E+00	7E-05	2E-05	-	-
	Ra-226	pCi/g	3.56E+00	3.05E+00	-	-	1E-06	1E-06
	Selenium	mg/kg	5.10E-01	3.26E-01	5E-06	3E-06	-	-
	Uranium	mg/kg	4.24E+00	3.47E+00	1E-03	8E-04	-	-
	Vanadium	mg/kg	7.82E+01	6.06E+01	7E-04	6E-04	-	-
Outside of APE (Wet and Dry Scenario)	Arsenic	mg/kg	3.23E+00	2.97E+00	4E-04	3E-04	2E-09	2E-09
	Mercury	mg/kg	1.16E-02	1.03E-02	2E-05	2E-05	-	-
	Molybdenum	mg/kg	3.38E-01	2.54E-01	3E-06	2E-06	-	-
	Ra-226	pCi/g	2.14E+00	1.99E+00	-	-	7E-07	7E-07
	Selenium	mg/kg	2.31E-01	1.73E-01	2E-06	2E-06	-	-
	Uranium	mg/kg	2.92E+00	2.54E+00	7E-04	6E-04	-	-
	Vanadium	mg/kg	4.82E+01	4.32E+01	5E-04	4E-04	-	-
AUM 457 (Wet and Dry Scenario)	Arsenic	mg/kg	6.57E+00	4.45E+00	8E-04	5E-04	5E-09	3E-09
	Mercury	mg/kg	1.71E-02	1.18E-02	2E-05	1E-05	-	-
	Molybdenum	mg/kg	2.44E+01	1.04E+01	2E-04	1E-04	-	-
	Ra-226	pCi/g	1.58E+01	7.67E+00	-	-	5E-06	3E-06
	Selenium	mg/kg	1.68E-01	1.15E-01	2E-06	1E-06	-	-
	Uranium	mg/kg	9.74E+00	6.46E+00	2E-03	2E-03	-	-
	Vanadium	mg/kg	3.82E+01	3.36E+01	4E-04	3E-04	-	-

Table 6-8a Uncertainty Assessment - Non-cancer HQ Results and Cancer Risk Results for Individual Non-Radiological and Radiological PCOCs - Adult Recreator Based on 1 Year of Exposure (Continued)

Evaluated Area	PCOCs	Units	Soil EPC Values		Hazard Quotient		Carcinogenic Risk Units	
			UCL	Mean	UCL	Mean	UCL	Mean
AUM 458 (Dry Scenario Only)	Arsenic	mg/kg	2.77E+01	1.95E+01	3E-03	2E-03	2E-08	1E-08
	Mercury	mg/kg	1.70E-01	1.10E-01	2E-04	1E-04	-	-
	Molybdenum	mg/kg	3.50E+02	9.58E+01	3E-03	9E-04	-	-
	Ra-226	pCi/g	7.39E+01	2.21E+01	-	-	2E-05	7E-06
	Selenium	mg/kg	5.18E-01	2.67E-01	5E-06	3E-06	-	-
	Uranium	mg/kg	8.62E+01	4.49E+01	2E-02	1E-02	-	-
	Vanadium	mg/kg	1.76E+01	1.50E+01	2E-04	1E-04	-	-
AUM 459 (Dry Scenario Only)	Arsenic	mg/kg	7.25E+00	7.25E+00	8E-04	8E-04	5E-09	5E-09
	Mercury	mg/kg	1.30E-02	1.30E-02	1E-05	1E-05	-	-
	Molybdenum	mg/kg	4.50E+01	4.50E+01	4E-04	4E-04	-	-
	Ra-226	pCi/g	1.50E+01	1.50E+01	-	-	5E-06	5E-06
	Selenium	mg/kg	ND	ND	-	-	-	-
	Uranium	mg/kg	9.00E+00	9.00E+00	2E-03	2E-03	-	-
	Vanadium	mg/kg	6.10E+00	6.10E+00	6E-05	6E-05	-	-
LCR Channel Area (Dry Scenario Only)	Arsenic	mg/kg	2.12E+00	1.96E+00	2E-04	2E-04	2E-09	1E-09
	Mercury	mg/kg	3.97E-03	3.22E-03	4E-06	4E-06	-	-
	Molybdenum	mg/kg	4.90E-01	2.30E-01	5E-06	2E-06	-	-
	Ra-226	pCi/g	1.05E+00	9.15E-01	-	-	3E-07	3E-07
	Selenium	mg/kg	ND	ND	-	-	-	-
	Uranium	mg/kg	9.21E-01	7.25E-01	2E-04	2E-04	-	-
	Vanadium	mg/kg	1.65E+01	1.42E+01	2E-04	1E-04	-	-

Notes: Arsenic and uranium were reported by the laboratory with unit of µg/kg but were converted to unit of mg/kg (by dividing by 1,000) in this table and for all risk calculations. Supporting calculations provided in Appendix F of the Phase III Summary Report. A dash indicates calculation was not required. Hazard Quotient (HQ) values less than one are below levels of regulatory concern. Cancer risk values below or within EPA acceptable range of 1E-6 and 1E-4 are not of regulatory concern. ND = Not detected.

Table 6-8b Uncertainty Assessment - Non-cancer HI Results and Sum Cancer Risk Results for Non-Radiological and Radiological PCOCs – Adult Recreator Based on 1 Year of Exposure

Evaluated Area	Hazard Index			Sum Cancer Risk	
	UCL	Mean		UCL	Mean
APE with AUMs (Dry Scenario)	6E-03	3E-03		4E-06	2E-06
APE with AUMs (Wet Scenario)	7E-03	3E-03		4E-06	2E-06
APE Less AUMs (Dry Scenario)	2E-03	1E-03		1E-06	8E-07
APE Less AUMs (Wet Scenario)	2E-03	2E-03		1E-06	1E-06
Outside of APE (Wet and Dry Scenario)	2E-03	1E-03		7E-07	7E-07
AUM 457 (Wet and Dry Scenario)	4E-03	3E-03		5E-06	2E-06
AUM 458 (Wet and Dry Scenario)	3E-02	1E-02		2E-05	7E-06
AUM 459 (Wet and Dry Scenario)	4E-03	4E-03		5E-06	5E-06
LCR Channel Area (Dry Scenario Only)	6E-04	5E-04		3E-07	3E-07

Notes:
Hazard Index (HI) is sum of individual PCOC HQ values.
HI values less than one are below levels of regulatory concern.
Sum of cancer risk values below or within EPA acceptable range of 1E-6 and 1E-4 are not of regulatory concern.

Table 6-9 Uncertainty Assessment – Relative Contributions of Ingestion, Dermal Contact, and Inhalation Pathways to Total Risks

			Non-Cancer Risks					Cancer Risk					
Scenario		**EPC**				**HQ_{sum}**	**%HQ from Inhalation**					**Risk (total)**	**%Risk from Inhalation**
	PCOC	**@UCL**	**Ingestion**	**Dermal**	**Inhalation**	**@UCL**		**Ingestion**	**Dermal**	**Inhalation**	**External**	**@UCL**	
AUM 458 (Dry Scenario Only)	Arsenic	2.77E+01	2.7E-03	5.6E-04	7.0E-08	3.2E-03	0.0022%	4.1E-07	8.7E-08	1.5E-12	---	5.0E-07	0.00031%
	Mercury	1.70E-01	---	---	1.9E-04	1.9E-04	---	---	---	---	---	---	---
	Molybdenum	3.50E+02	3.4E-03	---	---	3.4E-03	---	---	---	---	---	---	---
	Ra-226	7.39E+01	---	---	---	--	---	1.4E-05	---	2.9E-11	5.6E-04	5.7E-04	0.0000051%
	Selenium	5.18E-01	5.0E-06	---	9.8E-13	5.0E-06	0.000020%	---	---	---	---	---	---
	Uranium	8.62E+01	2.1E-02	---	8.1E-08	2.1E-02	0.000392%	---	---	---	---	---	---
	Vanadium	1.76E+01	1.7E-04	---	6.6E-09	1.7E-04	0.003946%	---	---	---	---	---	---

Notes:

Non-radionuclide EPCs converted to mg/kg for this table. Ra-226 soil concentration has unit of pCi/g and the risks reflect all daughter products.

Risk results shown are for long term adult recreator.

Values are shown to two significant digits to better display differences.

A dash (---) indicates calculation not required.

Table 6-10 Uncertainty Assessment – Comparison of HHSRE Soil Exposure Point Concentrations for Ra-226 for Soil Depths of Zero to 6 Inches and Zero to 12 Inches and Calculated Risks to Adult Recreators

	Soil Depth Interval Zero to Six Inches					Soil Depth Interval Zero to Twelve Inches			
Receptor Group and Evaluated Area	**EPC Mean**	**EPC UCL**	**Mean Cancer Risk**	**UCL Cancer Risk**		**EPC Mean**	**EPC UCL**	**Mean Cancer Risk**	**UCL Cancer Risk**
APE Area with AUMs (Dry Scenario)	5.18	10.9	4E-05	9E-05		6.19	13.4	5E-05	1E-04
APE Area with AUMs (Wet Scenario)	6.21	13.2	5E-05	1E-04		7.31	15.7	6E-05	1E-04
APE Area Less AUMs (Dry Scenario)	2.48	2.93	2E-05	2E-05		3.1	6	2E-05	5E-05
APE Area Less AUMs (Wet Scenario)	3.05	3.56	2E-05	3E-05		3.85	7.59	3E-05	6E-05
Outside of APE (Wet and Dry Scenario)	1.99	2.14	2E-05	2E-05		1.99	2.14	2E-05	2E-05
AUM 457 (Wet and Dry Scenario)	7.67	15.8	6E-05	1E-04		7.34	14.9	6E-05	1E-04
AUM 458 (Dry Scenario Only)	22.1	73.9	2E-04	6E-04		26.4	100	2E-04	8E-04
AUM 459 (Dry Scenario Only)	15	15	1E-04	1E-04		17.3	17.3	1E-04	1E-04
LCR Channel Area (Dry Scenario Only)	0.915	1.04	7E-06	8E-06		0.915	1.04	7E-06	8E-06

Notes:

Ra-226 concentration unit is pCi/g.

Recreator risks are based on 24 years of exposure.

EPCs and cancer risks for surface samples collected from 0 to 6 inches are from Table 6-5b.

Risks are calculated assuming concentrations are at the surface for conservatism.

Table 6-11a Summary of HHSRE Non-Radiological PCOC HQ Results for All Evaluated Receptors and Areas

		On-Site Workers (Table 6-4a)		Adult Recreator, ED of 24 years (Table 6-5a)		Child Recreator (Table 6-6a)		Combined Adult and Child Recreator (Table 6-7a)	
Evaluated Area	PCOCs	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean
APE Area with AUMs (Dry Scenario)	Arsenic	●	●	●	●	●	●	●	●
	Mercury	●	●	●	●	●	●	●	●
	Molybdenum	●	●	●	●	●	●	●	●
	Selenium	●	●	●	●	●	●	●	●
	Uranium	●	●	●	●	●	●	●	●
	Vanadium	●	●	●	●	●	●	●	●
APE Area with AUMs (Wet Scenario)	Arsenic	●	●	●	●	●	●	●	●
	Mercury	●	●	●	●	●	●	●	●
	Molybdenum	●	●	●	●	●	●	●	●
	Selenium	●	●	●	●	●	●	●	●
	Uranium	●	●	●	●	●	●	●	●
	Vanadium	●	●	●	●	●	●	●	●
APE Area Less AUMs (Dry Scenario Only)	Arsenic	●	●	●	●	●	●	●	●
	Mercury	●	●	●	●	●	●	●	●
	Molybdenum	●	●	●	●	●	●	●	●
	Selenium	●	●	●	●	●	●	●	●
	Uranium	●	●	●	●	●	●	●	●
	Vanadium	●	●	●	●	●	●	●	●
APE Area Less AUMs (Wet Scenario)	Arsenic	●	●	●	●	●	●	●	●
	Mercury	●	●	●	●	●	●	●	●
	Molybdenum	●	●	●	●	●	●	●	●
	Selenium	●	●	●	●	●	●	●	●
	Uranium	●	●	●	●	●	●	●	●
	Vanadium	●	●	●	●	●	●	●	●
Outside of APE Area (Wet and Dry Scenario)	Arsenic	●	●	●	●	●	●	●	●
	Mercury	●	●	●	●	●	●	●	●
	Molybdenum	●	●	●	●	●	●	●	●
	Selenium	●	●	●	●	●	●	●	●
	Uranium	●	●	●	●	●	●	●	●
	Vanadium	●	●	●	●	●	●	●	●
AUM 457 (Wet and Dry Scenario)	Arsenic	●	●	●	●	●	●	●	●
	Mercury	●	●	●	●	●	●	●	●
	Molybdenum	●	●	●	●	●	●	●	●
	Selenium	●	●	●	●	●	●	●	●
	Uranium	●	●	●	●	●	●	●	●
	Vanadium	●	●	●	●	●	●	●	●
AUM 458 (Dry Scenario Only)	Arsenic	●	●	●	●	●	●	●	●
	Mercury	●	●	●	●	●	●	●	●
	Molybdenum	●	●	●	●	●	●	●	●
	Selenium	●	●	●	●	●	●	●	●
	Uranium	●	●	●	●	●	●	●	●
	Vanadium	●	●	●	●	●	●	●	●
AUM 459 (Dry Scenario Only)	Arsenic	●	●	●	●	●	●	●	●
	Mercury	●	●	●	●	●	●	●	●
	Molybdenum	●	●	●	●	●	●	●	●
	Selenium	ND	ND	ND	ND	ND	ND	ND	ND
	Uranium	●	●	●	●	●	●	●	●
	Vanadium	●	●	●	●	●	●	●	●
LCR Channel Area (Dry Scenario Only)	Arsenic	●	●	●	●	●	●	●	●
	Mercury	●	●	●	●	●	●	●	●
	Molybdenum	●	●	●	●	●	●	●	●
	Selenium	ND	ND	ND	ND	ND	ND	ND	ND
	Uranium	●	●	●	●	●	●	●	●
	Vanadium	●	●	●	●	●	●	●	●

Notes:
Color coding: green = HQ ? 1; yellow = HQ > 1 and HQ ? 10; red = HQ > 10.
ND = Not detected
UCL = upper confidence limit of the mean

Table 6-11b Summary of HHSRE Arsenic and Ra-226 Cancer Risk Results for All Evaluated Receptors and Areas

		On-Site Workers (Table 6-4a)		Adult Recreator, ED of 24 years (Table 6-5a)		Child Recreator (Table 6-6a)		Combined Adult and Child Recreator (Table 6-7a)	
		UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean
APE Area with AUMs (Dry Scenario)	Arsenic	●	●	●	●	●	●	●	●
	Radium-226	●	●	●	●	●	●	●	●
APE Area with AUMs (Wet Scenario)	Arsenic	●	●	●	●	●	●	●	●
	Radium-226	●	●	●	●	●	●	●	●
APE Area Less AUMs (Dry Scenario Only)	Arsenic	●	●	●	●	●	●	●	●
	Radium-226	●	●	●	●	●	●	●	●
APE Area Less AUMs (Wet Scenario)	Arsenic	●	●	●	●	●	●	●	●
	Radium-226	●	●	●	●	●	●	●	●
Outside of APE Area (Wet and Dry Scenario)	Arsenic	●	●	●	●	●	●	●	●
	Radium-226	●	●	●	●	●	●	●	●
AUM 457 (Wet and Dry Scenario)	Arsenic	●	●	●	●	●	●	●	●
	Radium-226	●	●	●	●	●	●	●	●
AUM 458 (Dry Scenario Only)	Arsenic	●	●	●	●	●	●	●	●
	Radium-226	●	●	●	●	●	●	●	●
AUM 459 (Dry Scenario Only)	Arsenic	●	●	●	●	●	●	●	●
	Radium-226	●	●	●	●	●	●	●	●
LCR Channel Area (Dry Scenario Only)	Arsenic	●	●	●	●	●	●	●	●
	Radium-226	●	●	●	●	●	●	●	●

Notes:

Color coding: green = cancer risk $1x10^{-4}$; red = cancer risk > $1x10^{-4}$

UCL = upper confidence limit of the mean

Table 7-1 Summary of EcoSRE Soil Exposure Point Concentrations by Evaluated Area and Receptor Group

Receptor Group and Evaluated Area	PCOCs	Units	Freq of Detection	Mean or KM Mean	Distribution Type	Recommended UCL	Comment
Upland Receptors - APE Area with AUMs	Arsenic	mg/kg	62/62	4.66	No discernible	7.65	
	Mercury	mg/kg	56/62	0.0168	No discernible	0.0353	
	Molybdenum	mg/kg	45/62	11.4	No discernible	36.7	
	Ra-226	pCi/g	62/62	5.18	No discernible	10.9	
	Selenium	mg/kg	25/62	0.231	Gamma	0.316	[a]
	Uranium	mg/kg	62/62	6.89	No discernible	15.8	
	Vanadium	mg/kg	62/62	42.3	No discernible	57.2	
Upland Receptors - APE Area Less AUMs	Arsenic	mg/kg	45/45	3.00	No discernible	3.41	[b]
	Mercury	mg/kg	42/45	0.00773	No discernible	0.0141	
	Molybdenum	mg/kg	28/45	1.58	No discernible	5.43	
	Ra-226	pCi/g	45/45	2.48	Gamma	2.93	
	Selenium	mg/kg	18/45	0.253	Approximate Gamma	0.38	[a]
	Uranium	mg/kg	45/45	2.74	No discernible	4.33	
	Vanadium	mg/kg	45/45	48.23	No discernible	66.9	
Upland Receptors - Outside of APE	Arsenic	mg/kg	41/41	2.97	Normal	3.23	
	Mercury	mg/kg	40/41	0.0103	Normal	0.0116	
	Molybdenum	mg/kg	24/41	0.254	Gamma	0.338	[a]
	Ra-226	pCi/g	41/41	1.988	Approximate Normal	2.141	
	Selenium	mg/kg	11/41	0.173	Normal	0.231	
	Uranium	mg/kg	41/41	2.54	Lognormal	2.92	
	Vanadium	mg/kg	41/41	43.23	Normal	48.17	

Table 7-1 Summary of EcoSRE Soil Exposure Point Concentrations by Evaluated Area and Receptor Group (Continued)

Receptor Group and Evaluated Area	PCOCs	Units	Freq of Detection	Mean or KM Mean	Distribution Type	Recommended UCL	Comment
Upland Receptors - APE 457	Arsenic	mg/kg	11/11	4.45	Approximate Lognormal	6.57	
	Mercury	mg/kg	8/11	0.0118	Normal	0.0171	
	Molybdenum	mg/kg	11/11	10.4	Gamma	24.39	
	Ra-226	pCi/g	11/11	7.67	Gamma	15.75	
	Selenium	mg/kg	4/12	0.115	Normal	0.168	
	Uranium	mg/kg	11/11	6.46	Gamma	9.74	
	Vanadium	mg/kg	11/11	33.6	Normal	38.2	
Upland Receptors - APE 458	Arsenic	mg/kg	5/5	19.5	Normal	27.7	
	Mercury	mg/kg	5/5	0.110	Normal	0.170	
	Molybdenum	mg/kg	5/5	95.8	Gamma	350	[c]
	Ra-226	pCi/g	5/5	22.1	Approximate Lognormal	73.9	[c]
	Selenium	mg/kg	3/5	0.267	Normal	0.518	
	Uranium	mg/kg	5/5	44.9	Normal	86.2	
	Vanadium	mg/kg	5/5	15.0	No discernible	17.0	[c]
Upland Receptors - APE 459	Arsenic	mg/kg	1/1	7.25	---	7.25	[d]
	Mercury	mg/kg	1/1	0.01295	---	0.01295	[d]
	Molybdenum	mg/kg	1/1	45.0	---	45.0	[d]
	Ra-226	pCi/g	1/1	14.95	---	14.95	[d]
	Selenium	mg/kg	0/1	ND	---	ND	
	Uranium	mg/kg	1/1	9.00	---	9.00	[d]
	Vanadium	mg/kg	1/1	6.1	---	6.1	[d]

Table 7-1 Summary of EcoSRE Soil Exposure Point Concentrations by Evaluated Area and Receptor Group (Continued)

Receptor Group and Evaluated Area	PCOCs	Units	Freq of Detection	Mean or KM Mean	Distribution Type	Recommended UCL	Comment
Riparian Receptors - Riparian Buffer Area within APE	Arsenic	mg/kg	12/12	1.96	Normal	2.12	
	Mercury	mg/kg	11/12	0.00322	Normal	0.00397	
	Molybdenum	mg/kg	2/12	0.230	No discernible	0.490	
	Ra-226	pCi/g	12/12	0.915	Normal	1.05	
	Selenium	mg/kg	0/12	ND	---	---	
	Uranium	mg/kg	12/12	0.725	No discernible	0.921	[a]
	Vanadium	mg/kg	12/12	14.2	Approximate Gamma	16.5	

Notes:

Arsenic and uranium were reported by the laboratory with unit of µg/kg but were converted to unit of mg/kg (by dividing by 1,000) in this table and for all risk calculations.

When detection frequency is 100% the arithmetic mean is reported, otherwise the mean calculated using the Kaplan-Meier method is reported.

All calculations performed using EPA software ProUCL (v 5.1). Additional summary information and the associated ProUCL output are provided in Appendix Tables G3-2 and G3-3 of the Phase III Summary Report (provided as Appendix M to this report).

ND = not detected

[a] Two UCLs were suggested by ProUCL and the larger of the two were reported here and used for risk calculations.

[b] Three UCLs were suggested by ProUCL and the larger of the three was reported here and used for risk calculations.

[c] Recommended UCL exceeded the maximum detection. Latter was used as the UCL value.

[d] No output from ProUCL because single sample collected from this area. Used detected result as UCL value.

Table 7-2 Summary of Calculated EcoSRE Exposure Point Concentrations for Plants, Invertebrates and Small Mammals by Evaluated Area and Receptor Group

			Calculated Media Concentrations Using Biota Transfer Factors					
Receptor Group and Evaluated Area	**PCOCs**	**Units**	**Plants**		**Soil Invertebrates**		**Small Mammals**	
			Mean	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**
Upland Receptors - APE Area with AUMs	Arsenic	mg/kg (dry)	0.220	0.361	1.10	1.81	0.00138	0.00226
	Mercury	mg/kg (dry)	0.0111	0.0234	0.00790	0.0166	0.00101	0.00212
	Molybdenum	mg/kg (dry)	4.58	14.68	5.49	17.62	0.00273	0.00877
	Ra-226	pCi/g (wet)	0.28	0.593	10.94	23.0	0.0897	0.189
	Selenium	mg/kg (dry)	0.162	0.221	0.229	0.313	0.00148	0.00203
	Uranium	mg/kg (dry)	0.834	1.92	0.228	0.523	0.00010	0.00023
	Vanadium	mg/kg (dry)	0.232	0.315	1.78	2.40	0.00803	0.0109

Table 7-2 Summary of Calculated EcoSRE Exposure Point Concentrations for Plants, Invertebrates and Small Mammals by Evaluated Area and Receptor Group (Continued)

			Calculated Media Concentrations Using Biota Transfer Factors					
			Plants		Soil Invertebrates		Small Mammals	
Receptor Group and Evaluated Area	PCOCs	Units	Mean	UCL	Mean	UCL	Mean	UCL
Upland Receptors - APE Area Less AUMs	Arsenic	mg/kg (dry)	0.142	0.161	0.708	0.804	0.000887	0.00101
	Mercury	mg/kg (dry)	0.00512	0.0093	0.00363	0.0066	0.000464	0.00085
	Molybdenum	mg/kg (dry)	0.630	2.170	0.756	2.60	0.000377	0.00130
	Ra-226	pCi/g (wet)	0.135	0.160	5.24	6.19	0.0430	0.0507
	Selenium	mg/kg (dry)	0.177	0.264	0.250	0.373	0.00162	0.00242
	Uranium	mg/kg (dry)	0.331	0.524	0.090	0.143	0.0000397	0.0000628
	Vanadium	mg/kg (dry)	0.265	0.368	2.03	2.81	0.00916	0.0127
Upland Receptors - Outside of APE	Arsenic	mg/kg (dry)	0.140	0.152	0.701	0.763	0.00088	0.00096
	Mercury	mg/kg (dry)	0.00683	0.00769	0.00484	0.00545	0.000618	0.000696
	Molybdenum	mg/kg (dry)	0.102	0.135	0.122	0.162	0.0000607	0.0000808
	Ra-226	pCi/g (wet)	0.108	0.116	4.19	4.52	0.0344	0.0370
	Selenium	mg/kg (dry)	0.121	0.162	0.171	0.229	0.00111	0.00148

Table 7-2 Summary of Calculated EcoSRE Exposure Point Concentrations for Plants, Invertebrates and Small Mammals by Evaluated Area and Receptor Group (Continued)

			Calculated Media Concentrations Using Biota Transfer Factors					
Receptor Group and Evaluated Area	**PCOCs**	**Units**	**Plants**		**Soil Invertebrates**		**Small Mammals**	
			Mean	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**
	Uranium	ug/kg (dry)	0.307	0.354	0.084	0.096	0.0000368	0.0000424
	Vanadium	mg/kg (dry)	0.238	0.265	1.82	2.02	0.00821	0.00915
Upland Receptors - APE 457	Arsenic	mg/kg (dry)	0.21	0.31	1.05	1.55	0.001	0.002
	Mercury	mg/kg (dry)	0.00782	0.0113	0.00555	0.00804	0.000708	0.00103
	Molybdenum	mg/kg (dry)	4.152	9.756	4.982	11.707	0.00248	0.00583
	Ra-226	pCi/g (wet)	0.417	0.857	16.2	33.2	0.133	0.272
	Selenium	mg/kg (dry)	0.081	0.118	0.114	0.166	0.00074	0.00108
	Uranium	mg/kg (dry)	0.782	1.18	0.213	0.321	0.0001	0.0001
	Vanadium	mg/kg (dry)	0.185	0.210	1.41	1.60	0.00638	0.00725
Upland Receptors - APE 458	Arsenic	mg/kg (dry)	1	1	5	7	0.006	0.008
	Mercury	mg/kg (dry)	0.07293	0.11271	0.05170	0.07990	0.0066	0.0102
	Molybdenum	mg/kg (dry)	38.3	140	46.0	168	0.0229	0.084

Table 7-2 Summary of Calculated EcoSRE Exposure Point Concentrations for Plants, Invertebrates and Small Mammals by Evaluated Area and Receptor Group (Continued)

			Calculated Media Concentrations Using Biota Transfer Factors					
Receptor Group and Evaluated Area	**PCOCs**	**Units**	**Plants**		**Soil Invertebrates**		**Small Mammals**	
			Mean	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**
	Ra-226	pCi/g (wet)	1.20	4.02	46.53	155.9	0.3815	1.2785
	Selenium	mg/kg (dry)	0.187	0.363	0.264	0.513	0.00171	0.00333
	Uranium	mg/kg (dry)	5.43	10.4	1.48	2.84	0.0007	0.0012
	Vanadium	mg/kg (dry)	0.083	0.094	0.63	0.71	0.00285	0.00323
Upland Receptors - APE 459	Arsenic	mg/kg (dry)	0	0	2	2	0.002	0.002
	Mercury	mg/kg (dry)	0.00859	0.00859	0.00609	0.00609	0.000777	0.000777
	Molybdenum	mg/kg (dry)	18.0	18.0	21.6	21.6	0.0108	0.0108
	Ra-226	pCi/g (wet)	0.813	0.813	31.5	31.5	0.259	0.259
	Selenium	mg/kg (dry)	ND	ND	ND	ND	ND	ND
	Uranium	mg/kg (dry)	1.089	1.089	0.297	0.297	0.000131	0.000131
	Vanadium	mg/kg (dry)	0.034	0.034	0.26	0.26	0.00116	0.00116

Table 7-2 Summary of Calculated EcoSRE Exposure Point Concentrations for Plants, Invertebrates and Small Mammals by Evaluated Area and Receptor Group (Continued)

			Calculated Media Concentrations Using Biota Transfer Factors					
			Plants		Soil Invertebrates		Small Mammals	
Receptor Group and Evaluated Area	**PCOCs**	**Units**	**Mean**	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**
Riparian Receptors - Riparian Buffer Area within APE	Arsenic	mg/kg (dry)	0.1	0	0	1	0.001	0.001
	Mercury	mg/kg (dry)	0.00213	0.00263	0.00151	0.00187	0.000193	0.000238
	Molybdenum	mg/kg (dry)	0.092	0.196	0.110	0.235	0.000055	0.000117
	Ra-226	pCi/g (wet)	0.0498	0.057	1.93	2.21	0.0158	0.0181
	Selenium	mg/kg (dry)	ND	ND	ND	ND	ND	ND
	Uranium	mg/kg (dry)	0.088	0.111	0.024	0.030	0.0000105	0.0000134
	Vanadium	mg/kg (dry)	0.078	0.091	0.595	0.694	0.00269	0.00314

Notes:

Media concentrations calculated as product of soil EPCs and analyte-specific BTFs.

ND = not detected.

Table 7-3a Summary of Non-Radiological and Radiological Ecological Screening Levels for Soils Based on Plant Toxicity

		ESL values		
PCOCs	**Units**	**NOAEL**	**LOAEL**	**Source**
Arsenic	mg/kg	18	91	LANL (2017a)
Mercury	mg/kg	34	64	LANL (2017a)
Molybdenum	mg/kg	15	73	M-EMS (2014)
Ra-226	pCi/g	54	540	LANL (2017a)
Selenium	mg/kg	0.52	3	LANL (2017a)
Uranium	mg/kg	25	250	LANL (2017a)
Vanadium	mg/kg	60	80	LANL (2017a)

Notes:
LANL (2017a) did not report an ESL for molybdenum. See Appendix Table G6-2 of the Phase III Summary Report (provided as Appendix M to this report) for derivation of molybdenum plant NOAEL and LOAEL values.

Table 7-3b Summary of Non-Radiological TRVs for Mammalian and Avian Receptors

Mammalian Receptors										
	Deer Mouse			**Shrew**			**Coyote**			
PCOC	**TRV_{NOAEL}**	**TRV_{LOAEL}**		**TRV_{NOAEL}**	**TRV_{LOAEL}**		**TRV_{NOAEL}**	**TRV_{LOAEL}**		
Arsenic	1.01E+01	2.55E+01		1.01E+01	2.55E+01		1.86E+00	4.14E+00		
Mercury, inorganic	1.41E+01	NR		1.41E+01	NR		1.41E+01	NC		
Mercury, methyl	1.60E-01	NR		1.60E-01	NR		1.60E-01	NC		
Molybdenum	4.39E+00	1.49E+01		4.39E+00	1.49E+01		2.48E+00	7.38E+00		
Selenium	9.15E-01	2.00E+00		9.15E-01	2.00E+00		2.05E-01	4.46E-01		
Uranium	1.50E+01	NR		1.50E+01	NR		1.50E+01	NC		
Vanadium	4.16E+00	8.31E+00		4.16E+00	8.31E+00		9.30E-01	1.86E+00		
Avian Receptors										
	Mourning Dove			**American Kestrel**			**Rock Wren**			**Golden Eagle**
PCOC	TRV_{NOAEL}	TRV_{LOAEL}		TRV_{NOAEL}	TRV_{LOAEL}		TRV_{NOAEL}	TRV_{LOAEL}		TRV_{NOAEL}	TRV_{LOAEL}
Arsenic	3.62E+00	7.65E+00		3.62E+00	7.65E+00		3.62E+00	7.65E+00		3.62E+00	7.65E+00
Mercury, inorganic	4.50E-01	9.00E-01		4.50E-01	9.00E-01		4.50E-01	9.00E-01		4.50E-01	9.00E-01
Mercury, methyl	3.16E-02	1.40E-01		3.16E-02	1.40E-01		3.16E-02	1.40E-01		3.16E-02	1.40E-01
Molybdenum	5.45E+02	NR		5.45E+02	NR		5.45E+02	NR		5.45E+02	NR
Selenium	8.32E-01	1.99E+00		8.32E-01	1.99E+00		8.32E-01	1.99E+00		8.32E-01	1.99E+00
Uranium	7.80E+01	7.80E+02		7.80E+01	7.80E+02		7.80E+01	7.80E+02		7.80E+01	7.80E+02
Vanadium	1.24E+00	2.62E+00		1.24E+00	2.62E+00		1.24E+00	2.62E+00		1.24E+00	2.62E+00

Notes:
The TRV unit is mg/kg-day.
See Appendix Table G4 series and G5 series of the Phase III Summary Report (App M) for additional details on the derivation of the mammalian and avian TRVs.
NR = Not reported

Table 7-4 HQ Results for Upland and Riparian Area Exposures to Non-Radiological and Radiological PCOCs – Vegetation

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values		Plant ESL values		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	NOAEL	LOAEL	Mean	UCL	Mean	UCL
Upland - APE Area with AUMs	Arsenic	4.66E+00	7.65E+00	1.80E+01	9.10E+01	3.E-01	4.E-01	5.E-02	8.E-02
	Mercury	1.68E-02	3.53E-02	3.40E+01	6.40E+01	5.E-04	1.E-03	3.E-04	6.E-04
	Molybdenum	1.14E+01	3.67E+01	1.47E+01	7.34E+01	8.E-01	2.E+00	2.E-01	5.E-01
	Ra-226	5.18E+00	1.09E+01	5.40E+01	5.40E+02	1.E-01	2.E-01	1.E-02	2.E-02
	Selenium	2.31E-01	3.16E-01	5.20E-01	3.00E+00	4.E-01	6.E-01	8.E-02	1.E-01
	Uranium	6.89E+00	1.58E+01	2.50E+01	2.50E+02	3.E-01	6.E-01	3.E-02	6.E-02
	Vanadium	4.23E+01	5.72E+01	6.00E+01	8.00E+01	7.E-01	1.E+00	5.E-01	7.E-01
Upland - APE Area Less AUMs	Arsenic	3.00E+00	3.41E+00	1.80E+01	9.10E+01	2.E-01	2.E-01	3.E-02	4.E-02
	Mercury	7.73E-03	1.41E-01	3.40E+01	6.40E+01	2.E-04	4.E-03	1.E-04	2.E-03
	Molybdenum	1.58E+00	5.43E+00	1.47E+01	7.34E+01	1.E-01	4.E-01	2.E-02	7.E-02
	Ra-226	2.48E+00	2.93E+00	5.40E+01	5.40E+02	5.E-02	5.E-02	5.E-03	5.E-03
	Selenium	2.53E-01	3.77E-01	5.20E-01	3.00E+00	5.E-01	7.E-01	8.E-02	1.E-01
	Uranium	2.74E+00	4.33E+00	2.50E+01	2.50E+02	1.E-01	2.E-01	1.E-02	2.E-02
	Vanadium	4.82E+01	6.69E+01	6.00E+01	8.00E+01	8.E-01	1.E+00	6.E-01	8.E-01
Upland - Outside of APE	Arsenic	2.97E+00	3.23E+00	1.80E+01	9.10E+01	2.E-01	2.E-01	3.E-02	4.E-02
	Mercury	1.03E-02	1.16E-02	3.40E+01	6.40E+01	3.E-04	3.E-04	2.E-04	2.E-04
	Molybdenum	2.54E-01	3.38E-01	1.47E+01	7.34E+01	2.E-02	2.E-02	3.E-03	5.E-03
	Ra-226	1.99E+00	2.14E+00	5.40E+01	5.40E+02	4.E-02	4.E-02	4.E-03	4.E-03
	Selenium	1.73E-01	2.31E-01	5.20E-01	3.00E+00	3.E-01	4.E-01	6.E-02	8.E-02
	Uranium	2.54E+00	2.92E+00	2.50E+01	2.50E+02	1.E-01	1.E-01	1.E-02	1.E-02
	Vanadium	4.32E+01	4.82E+01	6.00E+01	8.00E+01	7.E-01	8.E-01	5.E-01	6.E-01

Table 7-4 HQ Results for Upland and Riparian Area Exposures to Non-Radiological and Radiological PCOCs – Vegetation (Continued)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values		Plant ESL values		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	NOAEL	LOAEL	Mean	UCL	Mean	UCL
Upland Receptors - APE 457	Arsenic	4.45E+00	6.57E+00	1.80E+01	9.10E+01	2.E-01	4.E-01	5.E-02	7.E-02
	Mercury	1.18E-02	1.71E-02	3.40E+01	6.40E+01	3.E-04	5.E-04	2.E-04	3.E-04
	Molybdenum	1.04E+01	2.44E+01	1.47E+01	7.34E+01	7.E-01	2.E+00	1.E-01	3.E-01
	Ra-226	7.67E+00	1.58E+01	5.40E+01	5.40E+02	1.E-01	3.E-01	1.E-02	3.E-02
	Selenium	1.15E-01	1.68E-01	5.20E-01	3.00E+00	2.E-01	3.E-01	4.E-02	6.E-02
	Uranium	6.46E+00	9.74E+00	2.50E+01	2.50E+02	3.E-01	4.E-01	3.E-02	4.E-02
	Vanadium	3.36E+01	3.82E+01	6.00E+01	8.00E+01	6.E-01	6.E-01	4.E-01	5.E-01
Upland Receptors - APE 458	Arsenic	1.95E+01	2.77E+01	1.80E+01	9.10E+01	1.E+00	2.E+00	2.E-01	3.E-01
	Mercury	1.10E-01	1.70E-01	3.40E+01	6.40E+01	3.E-03	5.E-03	2.E-03	3.E-03
	Molybdenum	9.58E+01	3.50E+02	1.47E+01	7.34E+01	6.E+00	2.E+01	1.E+00	5.E+00
	Ra-226	2.21E+01	7.39E+01	5.40E+01	5.40E+02	4.E-01	1.E+00	4.E-02	1.E-01
	Selenium	2.67E-01	5.18E-01	5.20E-01	3.00E+00	5.E-01	1.E+00	9.E-02	2.E-01
	Uranium	4.49E+01	8.62E+01	2.50E+01	2.50E+02	2.E+00	3.E+00	2.E-01	3.E-01
	Vanadium	1.50E+01	1.70E+01	6.00E+01	8.00E+01	3.E-01	3.E-01	2.E-01	2.E-01
Upland Receptors - APE 459	Arsenic	7.25E+00	7.25E+00	1.80E+01	9.10E+01	4.E-01	4.E-01	8.E-02	8.E-02
	Mercury	1.30E-02	1.30E-02	3.40E+01	6.40E+01	4.E-04	4.E-04	2.E-04	2.E-04
	Molybdenum	4.50E+01	4.50E+01	1.47E+01	7.34E+01	3.E+00	3.E+00	6.E-01	6.E-01
	Ra-226	1.50E+01	1.50E+01	5.40E+01	5.40E+02	3.E-01	3.E-01	3.E-02	3.E-02
	Selenium	ND	ND	5.20E-01	3.00E+00	ND	ND	ND	ND
	Uranium	9.00E+00	9.00E+00	2.50E+01	2.50E+02	4.E-01	4.E-01	4.E-02	4.E-02
	Vanadium	6.10E+00	6.10E+00	6.00E+01	8.00E+01	1.E-01	1.E-01	8.E-02	8.E-02

Table 7-4 HQ Results for Upland and Riparian Area Exposures to Non-Radiological and Radiological PCOCs – Vegetation (Continued)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values		Plant ESL values		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	NOAEL	LOAEL	Mean	UCL	Mean	UCL
Riparian - Riparian Buffer Area within APE	Arsenic	1.96E+00	2.12E+00	1.80E+01	9.10E+01	1.E-01	1.E-01	2.E-02	2.E-02
	Mercury	3.22E-03	3.97E-03	3.40E+01	6.40E+01	9.E-05	1.E-04	5.E-05	6.E-05
	Molybdenum	2.30E-01	4.90E-01	1.47E+01	7.34E+01	2.E-02	3.E-02	3.E-03	7.E-03
	Ra-226	9.15E-01	1.05E+00	5.40E+01	5.40E+02	2.E-02	2.E-02	2.E-03	2.E-03
	Selenium	ND	ND	5.20E-01	3.00E+00	---	---	---	---
	Uranium	7.25E-01	9.21E-01	2.50E+01	2.50E+02	3.E-02	4.E-02	3.E-03	4.E-03
	Vanadium	1.42E+01	1.65E+01	6.00E+01	8.00E+01	2.E-01	3.E-01	2.E-01	2.E-01

Notes:

Non-radiological concentration unit is mg/kg_{dw}. Ra-226 concentration unit is pCi/g_{dw}.

See Appendix Table G2 series of the Phase III Summary Report (provided as Appendix M to this report) for additional details regarding the calculation of EPC values.

ESL values were for "Generic Plants" from LANL (2017a), except for molybdenum which had no ESL value from this source. Alternate source was used (see Appendix Tables G6-1 and G6-2 of the Phase III Summary Report [Appendix M]).

HQ values less than one are below levels of regulatory concern.

HQ values greater than one are highlighted.

ND = Not detected

Table 7-5a HQ Results for Riparian Area Exposures to Non-Radiological PCOCs – Herbivorous Bird (Mourning Dove)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (mg/kg_{dw})		Diet EPC Values (mg/kg_{dw})		ADD (mg/kg-day)		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL
Riparian - Riparian Buffer Area within APE	Arsenic	2.00E+00	2.10E+00	9.30E-02	1.00E-01	8.6.E-04	9.3.E-04	2.4.E-04	2.6.E-04	1.1E-04	1.2E-04
	Mercury	3.20E-03	4.00E-03	2.10E-03	2.60E-03	1.4.E-05	1.8.E-05	4.6.E-04	5.6.E-04	1.0E-04	1.3E-04
	Molybdenum	2.30E-01	4.90E-01	9.20E-02	2.00E-01	6.3.E-04	1.3.E-03	1.2.E-06	2.5.E-06	NC	NC
	Selenium	ND	ND	ND	ND	--	--	--	--	--	--
	Uranium	7.20E-01	9.20E-01	8.80E-02	1.10E-01	6.7.E-04	8.5.E-04	8.6.E-06	1.1.E-05	8.6E-07	1.1E-06
	Vanadium	1.40E+01	1.70E+01	7.80E-02	9.10E-02	2.4.E-03	2.8.E-03	1.9.E-03	2.2.E-03	9.0E-04	1.1E-03

Notes:
See Appendix Table G3 series of the Phase III Summary Report (provided as Appendix M to this report) for additional details regarding the calculation of EPC values.
This receptor was not evaluated in the upland portions of the Site.
HQ values less than one are below levels of regulatory concern.
ND = Not detected
UCL = Upper Confidence Limit of the mean
EPC = Exposure Point Concentration
-- = Not applicable

Table 7-5b HQ Results for Riparian Area Exposures to Radiological PCOC (Ra-226) – Herbivorous Bird (Mourning Dove)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (pCi/g_{dw})		ssESL Values (pCi/g_{dw})		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	NOAEL	LOAEL	Mean	UCL	Mean	UCL
Riparian - Riparian Buffer Area within APE	Ra-226	9.15E-01	1.05E+00	3.9E+03	3.9E+04	2.E-04	3.E-04	2.E-05	3.E-05

Notes:
See Appendix Table G3 series of the Phase III Summary Report (provided as Appendix M to this report) for additional details regarding the calculation of EPC values.
ssESL values account for receptor AUF and SUF values. See Appendix Tables G6-3 and G6-4 of the Phase III Summary Report (Appendix M) for additional details.
This receptor was not evaluated in the upland portions of the Site.
ssESL = site-specific ecological screening levels
UCL = Upper Confidence Limit of the mean
EPC = Exposure Point Concentration

Table 7-6a HQ Results for Upland and Riparian Area Exposures to Non-Radiological PCOCs – Herbivorous Mammal (Deer Mouse)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (mg/kg$_{dw}$)		Diet EPC Values (mg/kg$_{dw}$)		ADD (mg/kg-day)		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL
Upland - APE Area with AUMs	Arsenic	4.70E+00	7.60E+00	2.20E-01	3.60E-01	7.8.E-02	1.3.E-01	8E-03	1E-02	3.E-03	5.E-03
	Mercury	1.70E-02	3.50E-02	1.10E-02	2.30E-02	2.9.E-03	6.0.E-03	2E-02	4E-02	NC	NC
	Molybdenum	1.10E+01	3.70E+01	4.60E+00	1.50E+01	1.2.E+00	3.9.E+00	3E-01	9E-01	8.E-02	3.E-01
	Selenium	2.30E-01	3.20E-01	1.60E-01	2.20E-01	4.2.E-02	5.7.E-02	5E-02	6E-02	2.E-02	3.E-02
	Uranium	6.90E+00	1.60E+01	8.30E-01	1.90E+00	2.4.E-01	5.6.E-01	2E-02	4E-02	NC	NC
	Vanadium	4.20E+01	5.70E+01	2.30E-01	3.10E-01	2.7.E-01	3.6.E-01	7E-02	9E-02	3.E-02	4.E-02
Upland - APE Area Less AUMs	Arsenic	3.00E+00	3.40E+00	1.40E-01	1.60E-01	5.0.E-02	5.7.E-02	5E-03	6E-03	2.E-03	2.E-03
	Mercury	7.70E-03	1.40E-02	5.10E-03	9.30E-03	1.3.E-03	2.4.E-03	8E-03	2E-02	NC	NC
	Molybdenum	1.60E+00	5.40E+00	6.30E-01	2.20E+00	1.7.E-01	5.7.E-01	4E-02	1E-01	1.E-02	4.E-02
	Selenium	2.50E-01	3.80E-01	1.80E-01	2.60E-01	4.6.E-02	6.8.E-02	5E-02	7E-02	2.E-02	3.E-02
	Uranium	2.70E+00	4.30E+00	3.30E-01	5.20E-01	9.6.E-02	1.5.E-01	6E-03	1E-02	NC	NC
	Vanadium	4.80E+01	6.70E+01	2.70E-01	3.70E-01	3.1.E-01	4.3.E-01	7E-02	1E-01	4.E-02	5.E-02
Upland - Outside of APE	Arsenic	3.00E+00	3.20E+00	1.40E-01	1.50E-01	5.0.E-02	5.4.E-02	5E-03	5E-03	2.E-03	2.E-03
	Mercury	1.00E-02	1.20E-02	6.80E-03	7.70E-03	1.8.E-03	2.0.E-03	1E-02	1E-02	NC	NC
	Molybdenum	2.50E-01	3.40E-01	1.00E-01	1.40E-01	2.7.E-02	3.5.E-02	6E-03	8E-03	2.E-03	2.E-03
	Selenium	1.70E-01	2.30E-01	1.20E-01	1.60E-01	3.1.E-02	4.2.E-02	3E-02	5E-02	2.E-02	2.E-02
	Uranium	2.50E+00	2.90E+00	3.10E-01	3.50E-01	8.9.E-02	1.0.E-01	6E-03	7E-03	NC	NC
	Vanadium	4.30E+01	4.80E+01	2.40E-01	2.60E-01	2.8.E-01	3.1.E-01	7E-02	7E-02	3.E-02	4.E-02
Upland Receptors - AUM 457	Arsenic	4.40E+00	6.60E+00	2.10E-01	3.10E-01	7.5.E-02	1.1.E-01	7E-03	1E-02	3.E-03	4.E-03
	Mercury	1.20E-02	1.70E-02	7.80E-03	1.10E-02	2.0.E-03	2.9.E-03	1E-02	2E-02	--	--
	Molybdenum	1.00E+01	2.40E+01	4.20E+00	9.80E+00	1.1.E+00	2.6.E+00	3E-01	6E-01	7.E-02	2.E-01
	Selenium	1.20E-01	1.70E-01	8.00E-02	1.20E-01	2.1.E-02	3.0.E-02	2E-02	3E-02	1.E-02	2.E-02
	Uranium	6.50E+00	9.70E+00	7.80E-01	1.20E+00	2.3.E-01	3.4.E-01	2E-02	2E-02	--	--
	Vanadium	3.40E+01	3.80E+01	1.80E-01	2.10E-01	2.1.E-01	2.4.E-01	5E-02	6E-02	3.E-02	3.E-02
Upland Receptors - AUM 458	Arsenic	2.00E+01	2.80E+01	9.20E-01	1.30E+00	3.3.E-01	4.7.E-01	3E-02	5E-02	1.E-02	2.E-02
	Mercury	1.10E-01	1.70E-01	7.30E-02	1.10E-01	1.9.E-02	2.9.E-02	1E-01	2E-01	--	--
	Molybdenum	9.60E+01	3.50E+02	3.80E+01	1.40E+02	1.0.E+01	3.7.E+01	2E+00	8E+00	7.E-01	3.E+00
	Selenium	2.70E-01	5.20E-01	1.90E-01	3.60E-01	4.8.E-02	9.3.E-02	5E-02	1E-01	2.E-02	5.E-02
	Uranium	4.50E+01	8.60E+01	5.40E+00	1.00E+01	1.6.E+00	3.0.E+00	1E-01	2E-01	--	--
	Vanadium	1.50E+01	1.70E+01	8.20E-02	9.40E-02	9.6.E-02	1.1.E-01	2E-02	3E-02	1.E-02	1.E-02
Upland Receptors - AUM 459	Arsenic	7.20E+00	7.20E+00	3.40E-01	3.40E-01	1.2.E-01	1.2.E-01	1E-02	1E-02	5.E-03	5.E-03
	Mercury	1.30E-02	1.30E-02	8.60E-03	8.60E-03	2.2.E-03	2.2.E-03	1E-02	1E-02	--	--
	Molybdenum	4.50E+01	4.50E+01	1.80E+01	1.80E+01	4.7.E+00	4.7.E+00	1E+00	1E+00	3.E-01	3.E-01
	Selenium	ND	ND	ND	ND	--	--	--	--	--	--
	Uranium	9.00E+00	9.00E+00	1.10E+00	1.10E+00	3.2.E-01	3.2.E-01	2E-02	2E-02	--	--
	Vanadium	6.10E+00	6.10E+00	3.40E-02	3.40E-02	3.9.E-02	3.9.E-02	9E-03	9E-03	5.E-03	5.E-03

Table 7-6a HQ Results for Upland and Riparian Area Exposures to Non-Radiological PCOCs – Herbivorous Mammal (Deer Mouse) (Continued)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (mg/kg_{dw})		Diet EPC Values (mg/kg_{dw})		ADD (mg/kg-day)		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL
Riparian - Riparian Buffer Area within APE	Arsenic	2.00E+00	2.10E+00	9.30E-02	1.00E-01	3.3.E-02	3.6.E-02	3E-03	4E-03	1.E-03	1.E-03
	Mercury	3.20E-03	4.00E-03	2.10E-03	2.60E-03	5.5.E-04	6.8.E-04	3E-03	4E-03	NC	NC
	Molybdenum	2.30E-01	4.90E-01	9.20E-02	2.00E-01	2.4.E-02	5.1.E-02	6E-03	1E-02	2.E-03	3.E-03
	Selenium	ND	ND	ND	ND	--	--	--	--	--	--
	Uranium	7.20E-01	9.20E-01	8.80E-02	1.10E-01	2.6.E-02	3.2.E-02	2E-03	2E-03	NC	NC
	Vanadium	1.40E+01	1.70E+01	7.80E-02	9.10E-02	9.0.E-02	1.1.E-01	2E-02	3E-02	1.E-02	1.E-02

Notes:

See Appendix Table G3 series of the Phase III Summary Report (provided as Appendix M to this report) for additional details regarding the calculation of EPC values.

HQ values less than one are below levels of regulatory concern.

HQ values greater than one are highlighted.

ADD = average daily dose

EPC = exposure point concentrations

ND = Not detected

NC = Not calculated (TRV_{LOAEL} not available)

UCL = upper confidence limit of the mean

-- = Not applicable

Table 7-6b HQ Results for Upland and Riparian Area Exposures to Radiological PCOC (Ra-226) – Herbivorous Mammal (Deer Mouse)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (pCi/g_{dw})		ssESL Values (pCi/g_{dw})		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	NOAEL	LOAEL	Mean	UCL	Mean	UCL
Upland - APE Area with AUMs	Ra-226	5.18E+00	1.09E+01	5.40E+02	5.40E+03	1.E-02	2.E-02	1.E-03	2.E-03
Upland - APE Area Less AUMs	Ra-226	2.48E+00	2.93E+00	5.40E+02	5.40E+03	5.E-03	5.E-03	5.E-04	5.E-04
Upland - Outside of APE	Ra-226	1.99E+00	2.14E+00	5.40E+02	5.40E+03	4.E-03	4.E-03	4.E-04	4.E-04
Upland - AUM 457	Ra-226	7.67E+00	1.58E+01	5.40E+02	5.40E+03	1.E-02	3.E-02	1.E-03	3.E-03
Upland - AUM 458	Ra-226	2.21E+01	7.39E+01	5.40E+02	5.40E+03	4.E-02	1.E-01	4.E-03	1.E-02
Upland - AUM 459	Ra-226	1.50E+01	1.50E+01	5.40E+02	5.40E+03	3.E-02	3.E-02	3.E-03	3.E-03
Riparian - Riparian Buffer Area within APE	Ra-226	9.15E-01	1.05E+00	5.40E+02	5.40E+03	2.E-03	2.E-03	2.E-04	2.E-04

Notes:
See Appendix Table G3 series of the Phase III Summary Report (provided as Appendix M to this report) for additional details regarding the calculation of EPC values.
ssESL values account for receptor AUF and SUF values. See Appendix Tables G6-3 and G6-4 of the Phase III Summary Report (Appendix M) for additional details.
HQ values less than one are below levels of regulatory concern.
ssESL = site-specific ecological screening levels for soils
UCL = Upper Confidence Limit of the mean

Table 7-7a HQ Results for Upland Area Exposures to Non-Radiological PCOCs – Insectivorous Bird (American Kestrel)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (mg/kg_{dw})		Diet EPC Values (mg/kg_{dw})		ADD (mg/kg-day)		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL
Upland - APE Area with AUMs	Arsenic	4.70E+00	7.60E+00	1.10E+00	1.80E+00	1.70E-01	2.80E-01	5.E-02	8.E-02	2.E-02	4.E-02
	Mercury	1.70E-02	3.50E-02	7.90E-03	1.70E-02	1.20E-03	2.50E-03	4.E-02	8.E-02	9.E-03	2.E-02
	Molybdenum	1.10E+01	3.70E+01	5.50E+00	1.80E+01	8.20E-01	2.60E+00	2.E-03	5.E-03	NC	NC
	Selenium	2.30E-01	3.20E-01	2.30E-01	3.10E-01	3.40E-02	4.60E-02	4.E-02	6.E-02	2.E-02	2.E-02
	Uranium	6.90E+00	1.60E+01	2.30E-01	5.20E-01	5.30E-02	1.20E-01	7.E-04	2.E-03	7.E-05	2.E-04
	Vanadium	4.20E+01	5.70E+01	1.80E+00	2.40E+00	3.80E-01	5.10E-01	3.E-01	4.E-01	1.E-01	2.E-01
Upland - APE Area Less AUMs	Arsenic	3.00E+00	3.40E+00	7.10E-01	8.00E-01	1.10E-01	1.30E-01	3.E-02	4.E-02	1.E-02	2.E-02
	Mercury	7.70E-03	1.40E-02	3.60E-03	6.60E-03	5.50E-04	9.90E-04	2.E-02	3.E-02	4.E-03	7.E-03
	Molybdenum	1.60E+00	5.40E+00	7.60E-01	2.60E+00	1.10E-01	3.90E-01	2.E-04	7.E-04	NC	NC
	Selenium	2.50E-01	3.80E-01	2.50E-01	3.70E-01	3.70E-02	5.50E-02	4.E-02	7.E-02	2.E-02	3.E-02
	Uranium	2.70E+00	4.30E+00	9.00E-02	1.40E-01	2.10E-02	3.30E-02	3.E-04	4.E-04	3.E-05	4.E-05
	Vanadium	4.80E+01	6.70E+01	2.00E+00	2.80E+00	4.30E-01	6.00E-01	4.E-01	5.E-01	2.E-01	2.E-01
Upland - Outside of APE	Arsenic	3.00E+00	3.20E+00	7.00E-01	7.60E-01	1.10E-01	1.20E-01	3.E-02	3.E-02	1.E-02	2.E-02
	Mercury	1.00E-02	1.20E-02	4.80E-03	5.50E-03	7.30E-04	8.20E-04	2.E-02	3.E-02	5.E-03	6.E-03
	Molybdenum	2.50E-01	3.40E-01	1.20E-01	1.60E-01	1.80E-02	2.40E-02	3.E-05	5.E-05	NC	NC
	Selenium	1.70E-01	2.30E-01	1.70E-01	2.30E-01	2.50E-02	3.40E-02	3.E-02	4.E-02	1.E-02	2.E-02
	Uranium	2.50E+00	2.90E+00	8.40E-02	9.60E-02	1.90E-02	2.20E-02	3.E-04	3.E-04	3.E-05	3.E-05
	Vanadium	4.30E+01	4.80E+01	1.80E+00	2.00E+00	3.90E-01	4.30E-01	3.E-01	4.E-01	2.E-01	2.E-01
Upland Receptors - AUM 457	Arsenic	4.40E+00	6.60E+00	1.10E+00	1.60E+00	2.20E-02	3.30E-02	6.E-03	9.E-03	3.E-03	4.E-03
	Mercury	1.20E-02	1.70E-02	5.50E-03	8.00E-03	1.10E-04	1.60E-04	4.E-03	5.E-03	8.E-04	1.E-03
	Molybdenum	1.00E+01	2.40E+01	5.00E+00	1.20E+01	1.00E-01	2.40E-01	2.E-04	4.E-04	NC	NC
	Selenium	1.20E-01	1.70E-01	1.10E-01	1.70E-01	2.30E-03	3.30E-03	3.E-03	4.E-03	1.E-03	2.E-03
	Uranium	6.50E+00	9.70E+00	2.10E-01	3.20E-01	6.70E-03	1.00E-02	9.E-05	1.E-04	9.E-06	1.E-05
	Vanadium	3.40E+01	3.80E+01	1.40E+00	1.60E+00	4.10E-02	4.70E-02	3.E-02	4.E-02	2.E-02	2.E-02
Upland Receptors - AUM 458	Arsenic	2.00E+01	2.80E+01	4.60E+00	6.50E+00	5.60E-02	7.90E-02	2.E-02	2.E-02	7.E-03	1.E-02
	Mercury	1.10E-01	1.70E-01	5.20E-02	8.00E-02	6.00E-04	9.30E-04	2.E-02	3.E-02	4.E-03	7.E-03
	Molybdenum	9.60E+01	3.50E+02	4.60E+01	1.70E+02	5.40E-01	2.00E+00	1.E-03	4.E-03	NC	NC
	Selenium	2.70E-01	5.20E-01	2.60E-01	5.10E-01	3.00E-03	5.90E-03	4.E-03	7.E-03	2.E-03	3.E-03
	Uranium	4.50E+01	8.60E+01	1.50E+00	2.80E+00	2.70E-02	5.10E-02	3.E-04	7.E-04	3.E-05	7.E-05
	Vanadium	1.50E+01	1.70E+01	6.30E-01	7.10E-01	1.00E-02	1.20E-02	8.E-03	1.E-02	4.E-03	0.0045

Table 7-7a HQ Results for Upland Area Exposures to Non-Radiological PCOCs – Insectivorous Bird (American Kestrel) (Continued)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (mg/kg_{dw})		Diet EPC Values (mg/kg_{dw})		ADD (mg/kg-day)		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL
Upland Receptors - AUM 459	Arsenic	7.20E+00	7.20E+00	1.70E+00	1.70E+00	4.80E-04	4.80E-04	1.E-04	1.E-04	6.E-05	6.E-05
	Mercury	1.30E-02	1.30E-02	6.10E-03	6.10E-03	1.70E-06	1.70E-06	5.E-05	5.E-05	1.E-05	1.E-05
	Molybdenum	4.50E+01	4.50E+01	2.20E+01	2.20E+01	5.90E-03	5.90E-03	1.E-05	1.E-05	NC	NC
	Selenium	ND	ND	ND	ND	--	--	--	--	--	--
	Uranium	9.00E+00	9.00E+00	3.00E-01	3.00E-01	1.20E-04	1.20E-04	2.E-06	2.E-06	2.E-07	2.E-07
	Vanadium	6.10E+00	6.10E+00	2.60E-01	2.60E-01	9.90E-05	9.90E-05	8.E-05	8.E-05	4.E-05	4.E-05

Notes:

See Appendix Table G3 series of the Phase III Summary Report (provided as Appendix M to this report) for additional details regarding the calculation of EPC values.

HQ values less than one are below levels of regulatory concern.

This receptor was not evaluated in the riparian portion of the Site.

ADD = average daily dose

EPC = exposure point concentrations

ND = Not detected

NC = Not calculated (TRV_{LOAEL} not available)

UCL = upper confidence limit of the mean

-- = Not applicable

Table 7-7b HQ Results for Upland Area Exposures to Radiological PCOC (Ra-226) – Insectivorous Bird (American Kestrel)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (pCi/g_{dw})		ssESL Values (pCi/g_{dw})		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	NOAEL	LOAEL	Mean	UCL	Mean	UCL
Upland - APE Area with AUMs	Ra-226	5.18E+00	1.09E+01	9.1E+02	9.1E+03	6.E-03	1.E-02	6.E-04	1.E-03
Upland - APE Area Less AUMs	Ra-226	2.48E+00	2.93E+00	9.1E+02	9.1E+03	3.E-03	3.E-03	3.E-04	3.E-04
Upland - Outside of APE	Ra-226	1.99E+00	2.14E+00	9.1E+02	9.1E+03	2.E-03	2.E-03	2.E-04	2.E-04
Upland - AUM 457	Ra-226	7.67E+00	1.58E+01	9.1E+02	9.1E+03	8.E-03	2.E-02	8.E-04	2.E-03
Upland - AUM 458	Ra-226	2.21E+01	7.39E+01	9.1E+02	9.1E+03	2.E-02	8.E-02	2.E-03	8.E-03
Upland - AUM 459	Ra-226	1.50E+01	1.50E+01	9.1E+02	9.1E+03	2.E-02	2.E-02	2.E-03	2.E-03

Notes:
See Appendix Table G3 series of the Phase III Summary Report (provided as Appendix M to this report) for additional details regarding the calculation of EPC values.
ssESL values account for receptor AUF and SUF values. See Appendix Tables G6-3 and G6-4 of the Phase III Summary Report for additional details.
HQ values less than one are below levels of regulatory concern.
This receptor was not evaluated in the riparian portion of the Site.
ssESL = site-specific ecological screening levels for soils
UCL = Upper Confidence Limit of the mean

Table 7-8a HQ Results for Upland Area Exposures to Non-Radiological PCOCs – Insectivorous Bird (Rock Wren)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (mg/kg_{dw})		Diet EPC Values (mg/kg_{dw})		ADD (mg/kg-day)		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL
Upland - APE Area with AUMs	Arsenic	4.70E+00	7.60E+00	1.10E+00	1.80E+00	3.1E-01	5.1E-01	9.E-02	1.E-01	4.E-02	7.E-02
	Mercury	1.70E-02	3.50E-02	7.90E-03	1.70E-02	2.1E-03	4.5E-03	7.E-02	1.E-01	2.E-02	3.E-02
	Molybdenum	1.10E+01	3.70E+01	5.50E+00	1.80E+01	1.5E+00	4.8E+00	3.E-03	9.E-03	NC	NC
	Selenium	2.30E-01	3.20E-01	2.30E-01	3.10E-01	6.1E-02	8.3E-02	7.E-02	1.E-01	3.E-02	4.E-02
	Uranium	6.90E+00	1.60E+01	2.30E-01	5.20E-01	9.5E-02	2.2E-01	1.E-03	3.E-03	1.E-04	3.E-04
	Vanadium	4.20E+01	5.70E+01	1.80E+00	2.40E+00	6.8E-01	9.3E-01	6.E-01	8.E-01	3.E-01	4.E-01
Upland - APE Area Less AUMs	Arsenic	3.00E+00	3.40E+00	7.10E-01	8.00E-01	2.0E-01	2.3E-01	6.E-02	6.E-02	3.E-02	3.E-02
	Mercury	7.70E-03	1.40E-02	3.60E-03	6.60E-03	9.9E-04	1.8E-03	3.E-02	6.E-02	7.E-03	1.E-02
	Molybdenum	1.60E+00	5.40E+00	7.60E-01	2.60E+00	2.1E-01	7.1E-01	4.E-04	1.E-03	NC	NC
	Selenium	2.50E-01	3.80E-01	2.50E-01	3.70E-01	6.7E-02	9.9E-02	8.E-02	1.E-01	3.E-02	5.E-02
	Uranium	2.70E+00	4.30E+00	9.00E-02	1.40E-01	3.8E-02	6.0E-02	5.E-04	8.E-04	5.E-05	8.E-05
	Vanadium	4.80E+01	6.70E+01	2.00E+00	2.80E+00	7.8E-01	1.1E+00	6.E-01	9.E-01	3.E-01	4.E-01
Upland - Outside of APE	Arsenic	3.00E+00	3.20E+00	7.00E-01	7.60E-01	2.0E-01	2.2E-01	6.E-02	6.E-02	3.E-02	3.E-02
	Mercury	1.00E-02	1.20E-02	4.80E-03	5.50E-03	1.3E-03	1.5E-03	4.E-02	5.E-02	9.E-03	1.E-02
	Molybdenum	2.50E-01	3.40E-01	1.20E-01	1.60E-01	3.3E-02	4.4E-02	6.E-05	8.E-05	NC	NC
	Selenium	1.70E-01	2.30E-01	1.70E-01	2.30E-01	4.6E-02	6.1E-02	6.E-02	7.E-02	2.E-02	3.E-02
	Uranium	2.50E+00	2.90E+00	8.40E-02	9.60E-02	3.5E-02	4.0E-02	5.E-04	5.E-04	5.E-05	5.E-05
	Vanadium	4.30E+01	4.80E+01	1.80E+00	2.00E+00	7.0E-01	7.8E-01	6.E-01	6.E-01	3.E-01	3.E-01
Upland Receptors - AUM 457	Arsenic	4.40E+00	6.60E+00	1.10E+00	1.60E+00	3.0E-01	4.4E-01	8.E-02	1.E-01	4.E-02	6.E-02
	Mercury	1.20E-02	1.70E-02	5.50E-03	8.00E-03	1.5E-03	2.2E-03	5.E-02	7.E-02	1.E-02	2.E-02
	Molybdenum	1.00E+01	2.40E+01	5.00E+00	1.20E+01	1.4E+00	3.2E+00	3.E-03	6.E-03	NC	NC
	Selenium	1.20E-01	1.70E-01	1.10E-01	1.70E-01	3.0E-02	4.4E-02	4.E-02	5.E-02	2.E-02	2.E-02
	Uranium	6.50E+00	9.70E+00	2.10E-01	3.20E-01	8.9E-02	1.3E-01	1.E-03	2.E-03	1.E-04	2.E-04
	Vanadium	3.40E+01	3.80E+01	1.40E+00	1.60E+00	5.4E-01	6.2E-01	4.E-01	5.E-01	2.E-01	2.E-01
Upland Receptors - AUM 458	Arsenic	2.00E+01	2.80E+01	4.60E+00	6.50E+00	1.3E+00	1.8E+00	4.E-01	5.E-01	2.E-01	2.E-01
	Mercury	1.10E-01	1.70E-01	5.20E-02	8.00E-02	1.4E-02	2.2E-02	5.E-01	7.E-01	1.E-01	2.E-01
	Molybdenum	9.60E+01	3.50E+02	4.60E+01	1.70E+02	1.2E+01	4.6E+01	2.E-02	3.E-01	NC	NC
	Selenium	2.70E-01	5.20E-01	2.60E-01	5.10E-01	7.0E-02	1.4E-01	8.E-02	2.E-01	4.E-02	7.E-02
	Uranium	4.50E+01	8.60E+01	1.50E+00	2.80E+00	6.2E-01	1.2E+00	8.E-03	2.E-02	8.E-04	2.E-03
	Vanadium	1.50E+01	1.70E+01	6.30E-01	7.10E-01	2.4E-01	2.7E-01	2.E-01	2.E-01	9.E-02	1.E-01

Table 7-8a HQ Results for Upland Area Exposures to Non-Radiological PCOCs – Insectivorous Bird (Rock Wren) (Continued)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (mg/kg_{dw})		Diet EPC Values (mg/kg_{dw})		ADD (mg/kg-day)		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL
Upland Receptors - AUM 459	Arsenic	7.20E+00	7.20E+00	1.70E+00	1.70E+00	1.2E-01	1.2E-01	3.E-02	3.E-02	2.E-02	2.E-02
	Mercury	1.30E-02	1.30E-02	6.10E-03	6.10E-03	4.2E-04	4.2E-04	1.E-02	1.E-02	3.E-03	3.E-03
	Molybdenum	4.50E+01	4.50E+01	2.20E+01	2.20E+01	1.5E+00	1.5E+00	3.E-03	3.E-03	NC	NC
	Selenium	ND	ND	ND	ND	--	--	--	--	--	--
	Uranium	9.00E+00	9.00E+00	3.00E-01	3.00E-01	3.2E-02	3.2E-02	4.E-04	4.E-04	4.E-05	4.E-05
	Vanadium	6.10E+00	6.10E+00	2.60E-01	2.60E-01	2.5E-02	2.5E-02	2.E-02	2.E-02	1.E-02	1.E-02
Riparian - Riparian Buffer Area within APE	Arsenic	2.00E+00	2.10E+00	4.60E-01	5.00E-01	1.3E-01	1.4E-01	4.E-02	4.E-02	2.E-02	2.E-02
	Mercury	3.20E-03	4.00E-03	1.50E-03	1.90E-03	4.1E-04	5.1E-04	1.E-02	2.E-02	3.E-03	4.E-03
	Molybdenum	2.30E-01	4.90E-01	1.10E-01	2.40E-01	3.0E-02	6.4E-02	6.E-05	1.E-04	NC	NC
	Selenium	ND	ND	ND	ND	--	--	--	--	--	--
	Uranium	7.20E-01	9.20E-01	2.40E-02	3.00E-02	1.0E-02	1.3E-02	1.E-04	2.E-04	1.E-05	2.E-05
	Vanadium	1.40E+01	1.70E+01	6.00E-01	6.90E-01	2.3E-01	2.7E-01	2.E-01	2.E-01	9.E-02	1.E-01

Notes:

See Appendix Table G3 series of the Phase III Summary Report (provided as Appendix M to this report) for additional details regarding the calculation of EPC values.

HQ values less than one are below levels of regulatory concern.

ADD = average daily dose

EPC = exposure point concentrations

ND = Not detected

NC = Not calculated (TRV_{LOAEL} not available)

UCL = upper confidence limit of the mean

-- = Not applicable

Table 7-8b HQ Results for Upland area Exposures to Radiological PCOC (Ra-226) – Insectivorous Bird (Rock Wren)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (pCi/g_{dw})		ssESL Values (pCi/g_{dw})		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	NOAEL	LOAEL	Mean	UCL	Mean	UCL
Upland - APE Area with AUMs	Ra-226	5.18E+00	1.09E+01	4.70E+01	4.70E+02	1.E-01	2.E-01	1.E-02	2.E-02
Upland - APE Area Less AUMs	Ra-226	2.48E+00	2.93E+00	4.70E+01	4.70E+02	5.E-02	6.E-02	5.E-03	6.E-03
Upland - Outside of APE	Ra-226	1.99E+00	2.14E+00	4.70E+01	4.70E+02	4.E-02	5.E-02	4.E-03	5.E-03
Upland - AUM 457	Ra-226	7.67E+00	1.58E+01	4.70E+01	4.70E+02	2.E-01	3.E-01	2.E-02	3.E-02
Upland - AUM 458	Ra-226	2.21E+01	7.39E+01	4.70E+01	4.70E+02	5.E-01	2.E+00	5.E-02	2.E-01
Upland - AUM 459	Ra-226	1.50E+01	1.50E+01	4.70E+01	4.70E+02	3.E-01	3.E-01	3.E-02	3.E-02
Riparian - Riparian Buffer Area within APE	Ra-226	9.15E-01	1.05E+00	4.70E+01	4.70E+02	2.E-02	2.E-02	2.E-03	2.E-03

Notes:
See Appendix Table G3 series for additional details regarding the calculation of EPC values.
ssESL values account for receptor AUF and SUF values. See Appendix Tables I6-3 and I6-4 of the Phase III Summary Report (provided as Appendix M to this report) for additional details.
HQ values less than one are below levels of regulatory concern.
HQ values greater than one are highlighted.
ssESL = site-specific ecological screening levels for soils
UCL = Upper Confidence Limit of the mean

Table 7-9a HQ Results for Upland and Riparian Area Exposures to Non-Radiological PCOCs – Insectivorous Mammal (Desert Shrew)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (mg/kg$_{dw}$)		Plant EPC Values (mg/kg$_{dw}$)		Invertebrate EPC Values (mg/kg$_{dw}$)		ADD		HQ$_{NOAEL}$		HQ$_{LOAEL}$	
		Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL
Upland - APE with AUMs	Arsenic	4.70E+00	7.60E+00	2.20E-01	3.60E-01	1.10E+00	1.80E+00	3.30E-01	5.40E-01	3.E-02	5.E-02	1.E-02	2.E-02
	Mercury	1.70E-02	3.50E-02	1.10E-02	2.30E-02	7.90E-03	1.70E-02	2.00E-03	4.30E-03	1.E-02	3.E-02	NC	NC
	Molybdenum	1.10E+01	3.70E+01	4.60E+00	1.50E+01	5.50E+00	1.80E+01	1.40E+00	4.40E+00	3.E-01	1.E+00	9.E-02	3.E-01
	Selenium	2.30E-01	3.20E-01	1.60E-01	2.20E-01	2.30E-01	3.10E-01	5.10E-02	6.90E-02	6.E-02	8.E-02	3.E-02	4.E-02
	Uranium	6.90E+00	1.60E+01	8.30E-01	1.90E+00	2.30E-01	5.20E-01	2.30E-01	5.30E-01	2.E-02	4.E-02	NC	NC
	Vanadium	4.20E+01	5.70E+01	2.30E-01	3.10E-01	1.80E+00	2.40E+00	1.40E+00	1.90E+00	3.E-01	5.E-01	2.E-01	2.E-01
Upland - APE Less AUMs	Arsenic	3.00E+00	3.40E+00	1.40E-01	1.60E-01	7.10E-01	8.00E-01	2.10E-01	2.40E-01	2.E-02	2.E-02	8.E-03	9.E-03
	Mercury	7.70E-03	1.40E-02	5.10E-03	9.30E-03	3.60E-03	6.60E-03	9.30E-04	1.70E-03	6.E-03	1.E-02	NC	NC
	Molybdenum	1.60E+00	5.40E+00	6.30E-01	2.20E+00	7.60E-01	2.60E+00	1.90E-01	6.50E-01	4.E-02	2.E-01	1.E-02	4.E-02
	Selenium	2.50E-01	3.80E-01	1.80E-01	2.60E-01	2.50E-01	3.70E-01	5.50E-02	8.30E-02	6.E-02	9.E-02	3.E-02	4.E-02
	Uranium	2.70E+00	4.30E+00	3.30E-01	5.20E-01	9.00E-02	1.40E-01	9.10E-02	1.40E-01	6.E-03	1.E-02	NC	NC
	Vanadium	4.80E+01	6.70E+01	2.70E-01	3.70E-01	2.00E+00	2.80E+00	1.60E+00	2.30E+00	4.E-01	5.E-01	2.E-01	3.E-01
Upland - Outside of APE	Arsenic	3.00E+00	3.20E+00	1.40E-01	1.50E-01	7.00E-01	7.60E-01	2.10E-01	2.30E-01	2.E-02	2.E-02	8.E-03	9.E-03
	Mercury	1.00E-02	1.20E-02	6.80E-03	7.70E-03	4.80E-03	5.50E-03	1.20E-03	1.40E-03	8.E-03	9.E-03	NC	NC
	Molybdenum	2.50E-01	3.40E-01	1.00E-01	1.40E-01	1.20E-01	1.60E-01	3.00E-02	4.10E-02	7.E-03	9.E-03	2.E-03	3.E-03
	Selenium	1.70E-01	2.30E-01	1.20E-01	1.60E-01	1.70E-01	2.30E-01	3.80E-02	5.10E-02	4.E-02	6.E-02	2.E-02	3.E-02
	Uranium	2.50E+00	2.90E+00	3.10E-01	3.50E-01	8.40E-02	9.60E-02	8.40E-02	9.70E-02	6.E-03	7.E-03	NC	NC
	Vanadium	4.30E+01	4.80E+01	2.40E-01	2.60E-01	1.80E+00	2.00E+00	1.50E+00	1.60E+00	4.E-01	4.E-01	2.E-01	2.E-01
Upland Receptors - AUM 457	Arsenic	4.40E+00	6.60E+00	2.10E-01	3.10E-01	1.10E+00	1.60E+00	3.10E-01	4.60E-01	3.E-02	5.E-02	1.E-02	2.E-02
	Mercury	1.20E-02	1.70E-02	7.80E-03	1.10E-02	5.50E-03	8.00E-03	1.40E-03	2.10E-03	9.E-03	1.E-02	NC	NC
	Molybdenum	1.00E+01	2.40E+01	4.20E+00	9.80E+00	5.00E+00	1.20E+01	1.20E+00	2.90E+00	3.E-01	7.E-01	8.E-02	2.E-01
	Selenium	1.20E-01	1.70E-01	8.00E-02	1.20E-01	1.10E-01	1.70E-01	2.50E-02	3.70E-02	3.E-02	4.E-02	1.E-02	2.E-02
	Uranium	6.50E+00	9.70E+00	7.80E-01	1.20E+00	2.10E-01	3.20E-01	2.10E-01	3.20E-01	1.E-02	2.E-02	NC	NC
	Vanadium	3.40E+01	3.80E+01	1.80E-01	2.10E-01	1.40E+00	1.60E+00	1.10E+00	1.30E+00	3.E-01	3.E-01	1.E-01	2.E-01
Upland Receptors - AUM 458	Arsenic	2.00E+01	2.80E+01	9.20E-01	1.30E+00	4.60E+00	6.50E+00	1.40E+00	2.00E+00	1.E-01	2.E-01	5.E-02	8.E-02
	Mercury	1.10E-01	1.70E-01	7.30E-02	1.10E-01	5.20E-02	8.00E-02	1.30E-02	2.10E-02	8.E-02	1.E-01	NC	NC
	Molybdenum	9.60E+01	3.50E+02	3.80E+01	1.40E+02	4.60E+01	1.70E+02	1.10E+01	4.20E+01	3.E+00	1.E+01	8.E-01	3.E+00
	Selenium	2.70E-01	5.20E-01	1.90E-01	3.60E-01	2.60E-01	5.10E-01	5.80E-02	1.10E-01	6.E-02	1.E-01	3.E-02	6.E-02
	Uranium	4.50E+01	8.60E+01	5.40E+00	1.00E+01	1.50E+00	2.80E+00	1.50E+00	2.90E+00	1.E-01	2.E-01	NC	NC
	Vanadium	1.50E+01	1.70E+01	8.20E-02	9.40E-02	6.30E-01	7.10E-01	5.10E-01	5.70E-01	1.E-01	1.E-01	6.E-02	7.E-02

Table 7-9a HQ Results for Upland and Riparian Area Exposures to Non-Radiological PCOCs – Insectivorous Mammal (Desert Shrew) (Continued)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (mg/kg$_{dw}$)		Plant EPC Values (mg/kg$_{dw}$)		Invertebrate EPC Values (mg/kg$_{dw}$)		ADD		HQ$_{NOAEL}$		HQ$_{LOAEL}$	
		Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL
Upland Receptors - AUM 459	Arsenic	7.20E+00	7.20E+00	3.40E-01	3.40E-01	1.70E+00	1.70E+00	1.80E-01	1.80E-01	2.E-02	2.E-02	7.E-03	7.E-03
	Mercury	1.30E-02	1.30E-02	8.60E-03	8.60E-03	6.10E-03	6.10E-03	5.40E-04	5.40E-04	3.E-03	3.E-03	NC	NC
	Molybdenum	4.50E+01	4.50E+01	1.80E+01	1.80E+01	2.20E+01	2.20E+01	1.90E+00	1.90E+00	4.E-01	4.E-01	1.E-01	1.E-01
	Selenium	ND	ND	ND	ND	--	--	--	--	--	--	--	--
	Uranium	9.00E+00	9.00E+00	1.10E+00	1.10E+00	3.00E-01	3.00E-01	1.00E-01	1.00E-01	7.E-03	7.E-03	NC	NC
	Vanadium	6.10E+00	6.10E+00	3.40E-02	3.40E-02	2.60E-01	2.60E-01	7.20E-02	7.20E-02	2.E-02	2.E-02	9.E-03	9.E-03
Riparian - Riparian Buffer Area within APE	Arsenic	2.00E+00	2.10E+00	9.30E-02	1.00E-01	4.60E-01	5.00E-01	2.60E-02	2.80E-02	3.E-03	3.E-03	1.E-03	1.E-03
	Mercury	3.20E-03	4.00E-03	2.10E-03	2.60E-03	1.50E-03	1.90E-03	7.30E-05	8.90E-05	5.E-04	6.E-04	NC	NC
	Molybdenum	2.30E-01	4.90E-01	9.20E-02	2.00E-01	1.10E-01	2.40E-01	5.20E-03	1.10E-02	1.E-03	3.E-03	4.E-04	7.E-04
	Selenium	ND	ND	ND	ND	--	--	--	--	--	--	--	--
	Uranium	7.20E-01	9.20E-01	8.80E-02	1.10E-01	2.40E-02	3.00E-02	4.50E-03	5.70E-03	3.E-04	4.E-04	NC	NC
	Vanadium	1.40E+01	1.70E+01	7.80E-02	9.10E-02	6.00E-01	6.90E-01	8.90E-02	1.00E-01	2.E-02	3.E-02	1.E-02	1.E-02

Notes:

See Appendix Table G3 series of the Phase III Summary Report (provided as Appendix M to this report) for additional details regarding the calculation of EPC values.

HQ values less than one are below levels of regulatory concern.

HQ values greater than one are highlighted.

ADD = average daily dose

EPC = exposure point concentrations

ND = Not detected

NC = Not calculated (TRV_{LOAEL} not available)

UCL = upper confidence limit of the mean

-- = Not applicable

Table 7-9b HQ Results for Upland and Riparian Area Exposures to Radiological PCOC (Ra-226) – Insectivorous Mammal (Desert Shrew)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (pCi/g_{dw})			ssESL Values (pCi/g_{dw})			HQ_{NOAEL}			HQ_{LOAEL}	
		Mean	UCL		NOAEL	LOAEL		Mean	UCL		Mean	UCL
Upland - APE with AUMs	Ra-226	5.18E+00	1.09E+01		5.90E+02	5.90E+03		9.E-03	2.E-02		9.E-04	2.E-03
Upland - APE Less AUMs	Ra-226	2.48E+00	2.93E+00		5.90E+02	5.90E+03		4.E-03	5.E-03		4.E-04	5.E-04
Upland - Outside of APE	Ra-226	1.99E+00	2.14E+00		5.90E+02	5.90E+03		3.E-03	4.E-03		3.E-04	4.E-04
Upland - AUM 457	Ra-226	7.67E+00	1.58E+01		5.90E+02	5.90E+03		1.E-02	3.E-02		1.E-03	3.E-03
Upland - AUM 458	Ra-226	2.21E+01	7.39E+01		5.90E+02	5.90E+03		4.E-02	1.E-01		4.E-03	1.E-02
Upland - AUM 459	Ra-226	1.50E+01	1.50E+01		5.90E+02	5.90E+03		3.E-02	3.E-02		3.E-03	3.E-03
Riparian - Riparian Buffer Area within APE	Ra-226	9.15E-01	1.05E+00		5.90E+02	5.90E+03		2.E-03	2.E-03		2.E-04	2.E-04

Notes:

See Appendix Table G3 series for additional details regarding the calculation of EPC values.

ssESL values account for receptor AUF and SUF values. See Appendix Tables G6-3 and G6-4 of the Phase III Summary Report (provided as Appendix M to this report) for additional details.

HQ values less than one indicate no significant risk.

ssESL = site-specific ecological screening levels for soils

UCL = Upper Confidence Limit of the mean

Table 7-10a HQ Results for Riparian Area Exposures to Non-Radiological PCOCs – Omnivorous Mammal (Coyote)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (mg/kg_{dw})		Diet EPC Values (mg/kg_{dw})		ADD		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL
Riparian - Riparian Buffer Area within APE	Arsenic	2.00E+00	2.10E+00	5.80E-04	6.30E-04	1.50E-05	1.60E-05	8.E-06	9.E-06	4.E-06	4.E-06
	Mercury	3.20E-03	4.00E-03	1.90E-04	2.40E-04	9.70E-08	1.20E-07	6.E-07	8.E-07	NC	NC
	Molybdenum	2.30E-01	4.90E-01	5.50E-05	1.20E-04	1.80E-06	3.70E-06	7.E-07	2.E-06	2.E-07	5.E-07
	Selenium	ND	ND	ND	ND	---	---	---	---	---	---
	Uranium	7.20E-01	9.20E-01	1.10E-05	1.30E-05	5.50E-06	7.00E-06	4.E-07	5.E-07	NC	NC
	Vanadium	1.40E+01	1.70E+01	2.70E-03	3.10E-03	1.10E-04	1.30E-04	1.E-04	1.E-04	6.E-05	7.E-05

Notes:

See Appendix Table G3 series of the Phase III Summary Report (provided as Appendix M to this report) for additional details regarding the calculation of EPC values.
HQ values less than one are below levels of regulatory concern.
This receptor was not evaluated in the upland portions of the Site.

ADD = average daily dose

EPC = exposure point concentrations

ND = Not detected

NC = Not calculated (TRV_{LOAEL} not available)

UCL = upper confidence limit of the mean

-- = Not applicable

Table 7-10b HQ Results for Riparian Area Exposure to Radiological PCOC (Ra-226) – Omnivorous Mammal (Coyote)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (pCi/g_{dw})			ssESL Values (pCi/g_{dw})			HQ_{NOAEL}			HQ_{LOAEL}	
		Mean	UCL		NOAEL	LOAEL		Mean	UCL		Mean	UCL
Riparian - Riparian Buffer Area within APE	Ra-226	9.15E-01	1.05E+00		2.80E+04	2.80E+05		3.E-05	4.E-05		3.E-06	4.E-06

Notes:
See Appendix Table G3 series of the Phase III Summary Report (provided as Appendix M to this report) for additional details regarding the calculation of EPC values.
ssESL values account for receptor AUF and SUF values. See Appendix Tables G6-3 and G6-4 of the Phase III Summary Report for additional details.
HQ values less than one are below levels of regulatory concern.
This receptor was not evaluated in the upland portions of the Site.
ssESL = site-specific ecological screening levels for soils
UCL = Upper Confidence Limit of the mean

Table 7-11a HQ Results for Upland Area Exposures to Non-Radiological PCOCs – Carnivorous Bird (Golden Eagle)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (mg/kg$_{dw}$)		Diet EPC Values (mg/kg$_{dw}$)		ADD		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL
Upland - APE with AUMs	Arsenic	4.70E+00	7.60E+00	1.40E-03	2.30E-03	2.8.E-08	4.7.E-08	8.E-09	1.E-08	4.E-09	6.E-09
	Mercury	1.70E-02	3.50E-02	1.00E-03	2.10E-03	2.1.E-08	4.4.E-08	7.E-07	1.E-06	2.E-07	3.E-07
	Molybdenum	1.10E+01	3.70E+01	2.70E-03	8.80E-03	5.6.E-08	1.8.E-07	1.E-10	3.E-10	NC	NC
	Selenium	2.30E-01	3.20E-01	1.50E-03	2.00E-03	3.1.E-08	4.2.E-08	4.E-08	5.E-08	2.E-08	2.E-08
	Uranium	6.90E+00	1.60E+01	1.00E-04	2.30E-04	2.1.E-09	4.7.E-09	3.E-11	6.E-11	3.E-12	6.E-12
	Vanadium	4.20E+01	5.70E+01	8.00E-03	1.10E-02	1.7.E-07	2.2.E-07	1.E-07	2.E-07	6.E-08	9.E-08
Upland - APE Less AUMs	Arsenic	3.00E+00	3.40E+00	8.90E-04	1.00E-03	1.7.E-08	1.9.E-08	5.E-09	5.E-09	2.E-09	3.E-09
	Mercury	7.70E-03	1.40E-02	4.60E-04	8.50E-04	8.7.E-09	1.6.E-08	3.E-07	5.E-07	6.E-08	1.E-07
	Molybdenum	1.60E+00	5.40E+00	3.80E-04	1.30E-03	7.1.E-09	2.4.E-08	1.E-11	5.E-11	NC	NC
	Selenium	2.50E-01	3.80E-01	1.60E-03	2.40E-03	3.1.E-08	4.6.E-08	4.E-08	6.E-08	2.E-08	2.E-08
	Uranium	2.70E+00	4.30E+00	4.00E-05	6.30E-05	7.5.E-10	1.2.E-09	1.E-11	2.E-11	1.E-12	2.E-12
	Vanadium	4.80E+01	6.70E+01	9.20E-03	1.30E-02	1.7.E-07	2.4.E-07	1.E-07	2.E-07	7.E-08	9.E-08
Upland - Outside of APE	Arsenic	3.00E+00	3.20E+00	8.80E-04	9.60E-04	2.4.E-08	2.6.E-08	7.E-09	7.E-09	3.E-09	3.E-09
	Mercury	1.00E-02	1.20E-02	6.20E-04	7.00E-04	1.7.E-08	1.9.E-08	5.E-07	6.E-07	1.E-07	1.E-07
	Molybdenum	2.50E-01	3.40E-01	6.10E-05	8.10E-05	1.6.E-09	2.2.E-09	3.E-12	4.E-12	NC	NC
	Selenium	1.70E-01	2.30E-01	1.10E-03	1.50E-03	3.0.E-08	4.0.E-08	4.E-08	5.E-08	2.E-08	2.E-08
	Uranium	2.50E+00	2.90E+00	3.70E-05	4.20E-05	9.9.E-10	1.1.E-09	1.E-11	2.E-11	1.E-12	2.E-12
	Vanadium	4.30E+01	4.80E+01	8.20E-03	9.20E-03	2.2.E-07	2.5.E-07	2.E-07	2.E-07	9.E-08	9.E-08
Upland Receptors - AUM 457	Arsenic	4.40E+00	6.60E+00	1.30E-03	1.90E-03	1.5.E-09	2.2.E-09	4.E-10	6.E-10	2.E-10	3.E-10
	Mercury	1.20E-02	1.70E-02	7.10E-04	1.00E-03	8.0.E-10	1.2.E-09	3.E-08	4.E-08	6.E-09	8.E-09
	Molybdenum	1.00E+01	2.40E+01	2.50E-03	5.80E-03	2.8.E-09	6.6.E-09	5.E-12	1.E-11	NC	NC
	Selenium	1.20E-01	1.70E-01	7.40E-04	1.10E-03	8.4.E-10	1.2.E-09	1.E-09	2.E-09	4.E-10	6.E-10
	Uranium	6.50E+00	9.70E+00	9.40E-05	1.40E-04	1.1.E-10	1.6.E-10	1.E-12	2.E-12	1.E-13	2.E-13
	Vanadium	3.40E+01	3.80E+01	6.40E-03	7.30E-03	7.3.E-09	8.2.E-09	6.E-09	7.E-09	3.E-09	3.E-09

Table 7-11a HQ Results for Upland Area Exposures to Non-Radiological PCOCs – Carnivorous Bird (Golden Eagle) (Continued)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (mg/kg$_{dw}$)		Diet EPC Values (mg/kg$_{dw}$)		ADD		HQ$_{NOAEL}$		HQ$_{LOAEL}$	
		Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL
Upland Receptors - AUM 458	Arsenic	2.00E+01	2.80E+01	5.80E-03	8.20E-03	3.7.E-09	5.3.E-09	1.E-09	2.E-09	5.E-10	7.E-10
	Mercury	1.10E-01	1.70E-01	6.60E-03	1.00E-02	4.3.E-09	6.6.E-09	1.E-07	2.E-07	3.E-08	5.E-08
	Molybdenum	9.60E+01	3.50E+02	2.30E-02	8.40E-02	1.5.E-08	5.4.E-08	3.E-11	1.E-10	NC	NC
	Selenium	2.70E-01	5.20E-01	1.70E-03	3.30E-03	1.1.E-09	2.1.E-09	1.E-09	3.E-09	6.E-10	1.E-09
	Uranium	4.50E+01	8.60E+01	6.50E-04	1.20E-03	4.2.E-10	8.1.E-10	5.E-12	1.E-11	5.E-13	1.E-12
	Vanadium	1.50E+01	1.70E+01	2.80E-03	3.20E-03	1.8.E-09	2.1.E-09	2.E-09	2.E-09	7.E-10	8.E-10
Upland Receptors - AUM 459	Arsenic	7.20E+00	7.20E+00	2.10E-03	2.10E-03	3.2.E-11	3.2.E-11	9.E-12	9.E-12	4.E-12	4.E-12
	Mercury	1.30E-02	1.30E-02	7.80E-04	7.80E-04	1.2.E-11	1.2.E-11	4.E-10	4.E-10	8.E-11	8.E-11
	Molybdenum	4.50E+01	4.50E+01	1.10E-02	1.10E-02	1.6.E-10	1.6.E-10	3.E-13	3.E-13	NC	NC
	Selenium	ND	ND	ND	ND	--	--	--	--	--	--
	Uranium	9.00E+00	9.00E+00	1.30E-04	1.30E-04	2.0.E-12	2.0.E-12	3.E-14	3.E-14	3.E-15	3.E-15
	Vanadium	6.10E+00	6.10E+00	1.20E-03	1.20E-03	1.7.E-11	1.7.E-11	1.E-11	1.E-11	7.E-12	7.E-12
Riparian - Riparian Buffer Area within APE	Arsenic	2.00E+00	2.10E+00	5.80E-04	6.30E-04	9.0.E-10	9.7.E-10	3.E-10	3.E-10	1.E-10	1.E-10
	Mercury	3.20E-03	4.00E-03	1.90E-04	2.40E-04	3.0.E-10	3.7.E-10	1.E-08	1.E-08	2.E-09	3.E-09
	Molybdenum	2.30E-01	4.90E-01	5.50E-05	1.20E-04	8.5.E-11	1.8.E-10	2.E-13	3.E-13	NC	NC
	Selenium	ND	ND	ND	ND	--	--	--	--	--	--
	Uranium	7.20E-01	9.20E-01	1.10E-05	1.30E-05	1.6.E-11	2.1.E-11	2.E-13	3.E-13	2.E-14	3.E-14
	Vanadium	1.40E+01	1.70E+01	2.70E-03	3.10E-03	4.2.E-09	4.9.E-09	3.E-09	4.E-09	2.E-09	2.E-09

Notes:

See Appendix Table G3 series of the Phase III Summary Report (provided as Appendix M to this report) for additional details regarding the calculation of EPC values.
HQ values less than one are below levels of regulatory concern.

ADD = average daily dose

EPC = exposure point concentrations

ND = Not detected

NC = Not calculated (TRV_{LOAEL} not available)

UCL = upper confidence limit of the mean

-- = Not applicable

Table 7-11b HQ Results for Upland Area Exposures to Radiological PCOC (Ra-226) – Carnivorous Bird (Golden Eagle)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values (pCi/g_{dw})			ssESL Values (pCi/g_{dw})			HQ_{NOAEL}			HQ_{LOAEL}	
		Mean	UCL		NOAEL	LOAEL		Mean	UCL		Mean	UCL
Upland - APE with AUMs	Ra-226	5.18E+00	1.09E+01		1.10E+06	1.10E+07		5.E-06	1.E-05		5.E-07	1.E-06
Upland - APE Less AUMs	Ra-226	2.48E+00	2.93E+00		1.20E+06	1.20E+07		2.E-06	2.E-06		2.E-07	2.E-07
Upland - Outside of APE	Ra-226	1.99E+00	2.14E+00		8.40E+05	8.40E+06		2.E-06	3.E-06		2.E-07	3.E-07
Upland - AUM 457	Ra-226	7.67E+00	1.58E+01		1.99E+07	1.99E+08		4.E-07	8.E-07		4.E-08	8.E-08
Upland - AUM 458	Ra-226	2.21E+01	7.39E+01		3.51E+07	3.51E+08		6.E-07	2.E-06		6.E-08	2.E-07
Upland - AUM 459	Ra-226	1.50E+01	1.50E+01		1.51E+09	1.51E+10		1.E-08	1.E-08		1.E-09	1.E-09
Riparian - Riparian Buffer Area within APE	Ra-227	9.15E-01	1.05E+00		1.50E+07	1.50E+08		6.E-08	7.E-08		6.E-09	7.E-09

Notes:

See Appendix Table G2 series for additional details regarding the calculation of EPC values.

ssESL values account for receptor AUF and SUF values. See Appendix Tables G6-3 and G6-4 of the Phase III Summary Report (provided as Appendix M to this report) for additional details.

HQ values less than one are below levels of regulatory concern.

ssESL = site-specific ecological screening levels for soils

UCL = Upper Confidence Limit of the mean

Table 7-12 Evaluation of Potential Risks to Spadefoot Toad from LCR Channel Sample Results under the Wet Scenario

PCOCs		Riparian Area Samples			Sediment Criteria		
	Units	Mean	UCL		NOAEL	LOAEL	Source
Arsenic	mg/kg_{dw}	1.96E+00	2.12E+00		9.70E+00	3.30E+01	[a]
Mercury	mg/kg_{dw}	3.22E-03	3.97E-03		1.80E-01	1.00E+00	[a]
Molybdenum	mg/kg_{dw}	2.30E-01	4.90E-01		1.00E+01	2.00E+02	[b]
Selenium	mg/kg_{dw}	ND	ND		7.20E-01	2.90E+00	[a]
Uranium	mg/kg_{dw}	7.25E-01	9.21E-01		1.00E+02	1.00E+03	[a]
Vanadium	mg/kg_{dw}	1.42E+01	1.65E+01		5.00E+01	NR	[c]
Ra-226	pCi/g_{dw}	9.15E-01	1.05E+00		5.00E+01	NR	[d]
					1.40E+03	1.40E+04	[e]

Notes:
Sediment benchmarks were derived from different sources.
ND = Not detected
NR = Not reported

[a] Values from LANL (2017a) for Aquatic community organisms - sediment
[b] Values shown are the Dutch Ministry target and intervention values for molybdenum in sediments reported in Friday (1998).
[c] Value from NOAA SQuIRT, background value for sediments.
[d] DOE (2002)
[e] Values from LANL (2017a) for Aquatic organisms - sediment

Table 7-13 Uncertainty Assessment of Receptor Selection – HQ Results for Upland and Riparian Area Exposures to Non-Radiological and Radiological PCOCs by Soil Invertebrates

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values		Earthworm ESLs		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	NOAEL	LOAEL	Mean	UCL	Mean	UCL
Upland - APE Area with AUMs	Arsenic	4.66E+00	7.65E+00	6.80E+00	6.80E+01	7.E-01	1.E+00	7.E-02	1.E-01
	Mercury	1.68E-02	3.53E-02	5.00E-02	5.00E-01	3.E-01	7.E-01	3.E-02	7.E-02
	Molybdenum	1.14E+01	3.67E+01	NR	2.15E+02	NR	NR	5.E-02	2.E-01
	Ra-226	5.18E+00	1.09E+01	1.50E+00	1.50E+01	3.E+00	7.E+00	3.E-01	7.E-01
	Selenium	2.31E-01	3.16E-01	4.10E+00	4.10E+01	6.E-02	8.E-02	6.E-03	8.E-03
	Uranium	6.89E+00	1.58E+01	1.10E+03	1.10E+04	6.E-03	1.E-02	6.E-04	1.E-03
	Vanadium	4.23E+01	5.72E+01	NR	NR	---	---	---	---
Upland - APE Area Less AUMs	Arsenic	3.00E+00	3.41E+00	6.80E+00	6.80E+01	4.E-01	5.E-01	4.E-02	5.E-02
	Mercury	7.73E-03	1.41E-01	5.00E-02	5.00E-01	2.E-01	3.E+00	2.E-02	3.E-01
	Molybdenum	1.58E+00	5.43E+00	NR	2.15E+02	NR	NR	7.E-03	3.E-02
	Ra-226	2.48E+00	2.93E+00	1.50E+00	1.50E+01	2.E+00	2.E+00	2.E-01	2.E-01
	Selenium	2.53E-01	3.77E-01	4.10E+00	4.10E+01	6.E-02	9.E-02	6.E-03	9.E-03
	Uranium	2.74E+00	4.33E+00	1.10E+03	1.10E+04	2.E-03	4.E-03	2.E-04	4.E-04
	Vanadium	4.82E+01	6.69E+01	NR	NR	---	---	---	---

Table 7-13 Uncertainty Assessment of Receptor Selection – HQ Results for Upland and Riparian Area Exposures to Non-Radiological and Radiological PCOCs by Soil Invertebrates (Continued)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values		Earthworm ESLs		HQ_{NOAEL}		HQ_{LOAEL}	
		Mean	UCL	NOAEL	LOAEL	Mean	UCL	Mean	UCL
Upland - Outside of APE	Arsenic	2.97E+00	3.23E+00	6.80E+00	6.80E+01	4.E-01	5.E-01	4.E-02	5.E-02
	Mercury	1.03E-02	1.16E-02	5.00E-02	5.00E-01	2.E-01	2.E-01	2.E-02	2.E-02
	Molybdenum	2.54E-01	3.38E-01	NR	2.15E+02	NR	NR	1.E-03	2.E-03
	Ra-226	1.99E+00	2.14E+00	1.50E+00	1.50E+01	1.E+00	1.E+00	1.E-01	1.E-01
	Selenium	1.73E-01	2.31E-01	4.10E+00	4.10E+01	4.E-02	6.E-02	4.E-03	6.E-03
	Uranium	2.54E+00	2.92E+00	1.10E+03	1.10E+04	2.E-03	3.E-03	2.E-04	3.E-04
	Vanadium	4.32E+01	4.82E+01	NR	NR	---	---	---	---
Upland Receptors - APE 457	Arsenic	4.45E+00	6.57E+00	6.80E+00	6.80E+01	7.E-01	1.E+00	7.E-02	1.E-01
	Mercury	1.18E-02	1.71E-02	5.00E-02	5.00E-01	2.E-01	3.E-01	2.E-02	3.E-02
	Molybdenum	1.04E+01	2.44E+01	NR	2.15E+02	NR	NR	5.E-02	1.E-01
	Ra-226	7.67E+00	1.58E+01	1.50E+00	1.50E+01	5.E+00	1.E+01	5.E-01	1.E+00
	Selenium	1.15E-01	1.68E-01	4.10E+00	4.10E+01	3.E-02	4.E-02	3.E-03	4.E-03
	Uranium	6.46E+00	9.74E+00	1.10E+03	1.10E+04	6.E-03	9.E-03	6.E-04	9.E-04
	Vanadium	3.36E+01	3.82E+01	NR	NR	---	---	---	---
Upland Receptors - APE 458	Arsenic	1.95E+01	2.77E+01	6.80E+00	6.80E+01	3.E+00	4.E+00	3.E-01	4.E-01
	Mercury	1.10E-01	1.70E-01	5.00E-02	5.00E-01	2.E+00	3.E+00	2.E-01	3.E-01
	Molybdenum	9.58E+01	1.03E+03	NR	2.15E+02	NR	NR	4.E-01	5.E+00
	Ra-226	2.21E+01	7.39E+01	1.50E+00	1.50E+01	1.E+01	5.E+01	1.E+00	5.E+00
	Selenium	2.67E-01	5.18E-01	4.10E+00	4.10E+01	7.E-02	1.E-01	7.E-03	1.E-02
	Uranium	4.49E+01	8.62E+01	1.10E+03	1.10E+04	4.E-02	8.E-02	4.E-03	8.E-03

Table 7-13 Uncertainty Assessment of Receptor Selection – HQ Results for Upland and Riparian Area Exposures to Non-Radiological and Radiological PCOCs by Soil Invertebrates (Continued)

Receptor Group and Evaluated Area	PCOCs	Soil EPC Values			Earthworm ESLs			HQ_{NOAEL}			HQ_{LOAEL}	
		Mean	UCL		NOAEL	LOAEL		Mean	UCL		Mean	UCL
	Vanadium	1.50E+01	1.76E+01		NR	NR		---	---	---	---	---
Upland Receptors - APE 459	Arsenic	7.25E+00	7.25E+00		6.80E+00	6.80E+01		1.E+00	1.E+00		1.E-01	1.E-01
	Mercury	1.30E-02	1.30E-02		5.00E-02	5.00E-01		3.E-01	3.E-01		3.E-02	3.E-02
	Molybdenum	4.50E+01	4.50E+01		NR	2.15E+02		NR	NR		2.E-01	2.E-01
	Ra-226	1.50E+01	1.50E+01		1.50E+00	1.50E+01		1.E+01	1.E+01		1.E+00	1.E+00
	Selenium	ND	ND		4.10E+00	4.10E+01		ND	ND		ND	ND
	Uranium	9.00E+00	9.00E+00		1.10E+03	1.10E+04		8.E-03	8.E-03		8.E-04	8.E-04
	Vanadium	6.10E+00	6.10E+00		NR	NR		---	---	---	---	---
Riparian - Riparian Buffer Area within APE	Arsenic	1.96E+00	2.12E+00		6.80E+00	6.80E+01		3.E-01	3.E-01		3.E-02	3.E-02
	Mercury	3.22E-03	3.97E-03		5.00E-02	5.00E-01		6.E-02	8.E-02		6.E-03	8.E-03
	Molybdenum	2.30E-01	4.90E-01		NR	2.15E+02		NR	NR		1.E-03	2.E-03
	Ra-226	9.15E-01	1.05E+00		1.50E+00	1.50E+01		6.E-01	7.E-01		6.E-02	7.E-02
	Selenium	ND	ND		4.10E+00	4.10E+01		---	---		---	---
	Uranium	7.25E-01	9.21E-01		1.10E+03	1.10E+04		7.E-04	8.E-04		7.E-05	8.E-05
	Vanadium	1.42E+01	1.65E+01		NR	NR		---	---	---	---	---

Notes:

Non-radiological concentration unit is mg/kg_{dw}. Ra-226 concentration unit is pCi/g_{dw}. See Appendix Table G2 series of the Phase III Summary Report (provided as Appendix M to this report) for additional details regarding the calculation of EPC values. ESL values were for earthworms (except for molybdenum) and assumed applicable to all terrestrial invertebrates (e.g., insects). See Appendix Table G7 series of the Phase III Summary Report for additional information.

HQ values less than one is below regulatory risk level. HQ values greater than one are highlighted. ND = Not detected. NR = Not reported

Table 7-14 Uncertainty Assessment – Comparison of Ra-226 ssESLs to LANL (2017a) ESLs of Similar Species

	Babbitt Site				LANL (2017a) Model		
		ssESL Values (pCi/g_{dw})				LANL ESL Values (pCi/g_{dw})	
Babbitt Receptor	**Evaluated Area**	**NOAEL**	**LOAEL**		**LANL Receptor**	**NOAEL**	**LOAEL**
Deer Mouse	All evaluated areas	540	5,400		Deer Mouse	380	3,800
American Kestrel	Upland areas only	910	9,100		American Kestrel	870	8,700
Desert Shrew	All evaluated areas	590	5,900		Montane Shrew	510	5,100
Coyote	Riparian areas only	28,000	280,000		Gray Fox	370	3,700

Note:

The Coyote ssESL accounts for the AUF which is not included in the Gray Fox LANL ESL calculation.

The LANL ESL values uses different (though similar) exposure assumptions and TRVs compared to those used to develop the ssESLs.

The "Evaluated Area" refers to those portions of the Site where exposures to PCOCs were assessed.

Table 7-15a Summary of EcoSRE HQ Results for All Evaluated Receptors and Non-Radiological PCOCs

		Plants				Mourning Dove				Deer Mouse				American Kestrel				Rock Wren				Desert Shrew				Coyote				Golden Eagle			
		HQ_{NOAEL}		HQ_{LOAEL}		HQ_{NOAEL}		HQ_{LOAEL}		HQ_{NOAEL}		HQ_{LOAEL}		HQ_{NOAEL}		HQ_{LOAEL}		HQ_{NOAEL}		HQ_{LOAEL}		HQ_{NOAEL}		HQ_{LOAEL}		HQ_{NOAEL}		HQ_{LOAEL}		HQ_{NOAEL}		HQ_{LOAEL}	
Evaluated Area	PCOCs	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL	Mean	UCL
Upland - APE Area with AUMs	Arsenic	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
	Mercury	●	●	●	●	NR	NR	NR	NR	●	●	NC	NC	●	●	●	●	●	●	●	●	●	●	NC	NC	NR	NR	NR	NR	●	●	●	●
	Molybdenum	●	◐	●	●	NR	NR	NR	NR	●	●	●	●	●	●	NC	NC	●	●	NC	NC	●	◐	●	●	NR	NR	NR	NR	●	●	NC	NC
	Selenium	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
	Uranium	●	●	●	●	NR	NR	NR	NR	●	●	NC	NC	●	●	●	●	●	●	●	●	●	●	NC	NC	NR	NR	NR	NR	●	●	●	●
	Vanadium	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
Upland - APE Area Less AUMs	Arsenic	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
	Mercury	●	●	●	●	NR	NR	NR	NR	●	●	NC	NC	●	●	●	●	●	●	●	●	●	●	NC	NC	NR	NR	NR	NR	●	●	●	●
	Molybdenum	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	NC	NC	●	●	NC	NC	●	●	●	●	NR	NR	NR	NR	●	●	NC	NC
	Selenium	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
	Uranium	●	●	●	●	NR	NR	NR	NR	●	●	NC	NC	●	●	●	●	●	●	●	●	●	●	NC	NC	NR	NR	NR	NR	●	●	●	●
	Vanadium	●	◐	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
Upland - Outside of APE Area	Arsenic	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
	Mercury	●	●	●	●	NR	NR	NR	NR	●	●	NC	NC	●	●	●	●	●	●	●	●	●	●	NC	NC	NR	NR	NR	NR	●	●	●	●
	Molybdenum	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	NC	NC	●	●	NC	NC	●	●	●	●	NR	NR	NR	NR	●	●	NC	NC
	Selenium	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
	Uranium	●	●	●	●	NR	NR	NR	NR	●	●	NC	NC	●	●	●	●	●	●	●	●	●	●	NC	NC	NR	NR	NR	NR	●	●	●	●
	Vanadium	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
Upland Receptors - AUM 457	Arsenic	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
	Mercury	●	●	●	●	NR	NR	NR	NR	●	●	--	--	●	●	●	●	●	●	●	●	●	●	NC	NC	NR	NR	NR	NR	●	●	●	●
	Molybdenum	●	◐	●	●	NR	NR	NR	NR	●	●	●	●	●	●	NC	NC	●	●	NC	NC	●	●	●	●	NR	NR	NR	NR	●	●	NC	NC
	Selenium	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
	Uranium	●	●	●	●	NR	NR	NR	NR	●	●	--	--	●	●	●	●	●	●	●	●	●	●	NC	NC	NR	NR	NR	NR	●	●	●	●
	Vanadium	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
Upland Receptors - AUM 458	Arsenic	◐	◐	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
	Mercury	●	●	●	●	NR	NR	NR	NR	●	●	--	--	●	●	●	●	●	●	●	●	●	●	NC	NC	NR	NR	NR	NR	●	●	●	●
	Molybdenum	◐	●	◐	◐	NR	NR	NR	NR	◐	◐	●	◐	●	●	NC	NC	●	●	NC	NC	◐	◐	●	◐	NR	NR	NR	NR	●	●	NC	NC
	Selenium	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
	Uranium	◐	◐	●	●	NR	NR	NR	NR	●	●	--	--	●	●	●	●	●	●	●	●	●	●	NC	NC	NR	NR	NR	NR	●	●	●	●
	Vanadium	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
Upland Receptors - AUM 459	Arsenic	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
	Mercury	●	●	●	●	NR	NR	NR	NR	●	●	--	--	●	●	●	●	●	●	●	●	●	●	NC	NC	NR	NR	NR	NR	●	●	●	●
	Molybdenum	◐	◐	●	●	NR	NR	NR	NR	◐	◐	●	●	●	●	NC	NC	●	●	NC	NC	●	●	●	●	NR	NR	NR	NR	●	●	NC	NC
	Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NR	NR	NR	NR	ND	ND	ND	ND
	Uranium	●	●	●	●	NR	NR	NR	NR	●	●	--	--	●	●	●	●	●	●	●	●	●	●	NC	NC	NR	NR	NR	NR	●	●	●	●
	Vanadium	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
Riparian - Riparian Buffer Area within APE	Arsenic	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Mercury	●	●	●	●	●	●	●	●	●	●	NC	NC	●	●	NC	NC	●	●	●	●	●	●	NC	NC	●	●	NC	NC	●	●	●	●
	Molybdenum	●	●	●	●	●	●	NC	NC	●	●	●	●	●	●	●	●	●	●	NC	NC	●	●	●	●	●	●	●	●	●	●	NC	NC
	Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Uranium	●	●	●	●	●	●	●	●	●	●	NC	NC	●	●	NC	NC	●	●	●	●	●	●	NC	NC	●	●	NC	NC	●	●	●	●
	Vanadium	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Notes:

Color coding: green = HQ less than one; yellow = HQ between one and ten; red = HQ greater than 10.

ND = Not detected

NC = Not calculated (TRV_{LOAEL} not avaliable)

NR = Not reported. Receptor not evaluated in this area.

UCL = upper confidence limit of the mean

-- = Not applicable

Table 7-15b Summary of EcoSRE HQ Results for All Evaluated Receptors and Radiological PCOCs

		Plants				Mourning Dove				Deer Mouse				American Kestrel				Rock Wren				Desert Shrew				Coyote				Golden Eagle			
		HQ_{NOAEL}		HQ_{LOAEL}		HQ_{NOAEL}		HQ_{LOAEL}		HQ_{NOAEL}		HQ_{LOAEL}		HQ_{NOAEL}		HQ_{LOAEL}		HQ_{NOAEL}		HQ_{LOAEL}		HQ_{NOAEL}		HQ_{LOAEL}		HQ_{NOAEL}		HQ_{LOAEL}		HQ_{NOAEL}		HQ_{LOAEL}	
Evaluated Area	**PCOCs**	**Mean**	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**	**Mean**	**UCL**
Upland - APE Area with AUMs	Radium-226	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
Upland - APE Area Less AUMs	Radium-226	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
Upland - Outside of APE Area	Radium-226	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
Upland Receptors - AUM 457	Radium-226	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
Upland Receptors - AUM 458	Radium-226	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
Upland Receptors - AUM 459	Radium-226	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●
Riparian - Riparian Buffer Area within APE	Radium-226	●	●	●	●	●	●	●	●	●	●	●	●	NR	NR	NR	NR	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Notes:

Color coding: green = HQ less than one; yellow = HQ between one and ten; red = HQ greater than 10.

ND = Not detected

NC = Not calculated (TRV_{LOAEL} not avaliable)

NR = Not reported. Receptor not evaluated in this area.

UCL = upper confidence limit of the mean

-- = Not applicable

Table 8-1a Comparison of Human Health Risk Based Action Levels for Ra-226 and Daughter Products in Soils to Comparable Ecological Receptor Risk Based Action Levels

Human Health Receptor and Scenario	AUM 458 HHSRE Risks			Associated HHSRE Table	Human Health rbALs at Different Risk Thresholds			Ra-226 ssESLs at HQ of One and for Ecological Receptors with AUF values of One				Geomean Ecological NOAELs	Potential rbAL
	Risk Type	UCL	Cancer Risk		1E-06	1E-05	IE-04	Rock Wren NOAEL	Rock Wren LOAEL	Desert Shrew NOAEL	Desert Shrew LOAEL		
On-Site Workers	C	7.39E+01	4.2E-07	6-4a	170	1,700	17,000	47	470	540	5,400	159	160
Long Term Recreator - Adult Only (14 days per year, 24 years as adult)	C	7.39E+01	5.7E-04	6-5a	0.13	1.3	13	47	470	540	5,400	159	13
Long Term Recreator - Child Only (14 days per year; 2 years as child)	C	7.39E+01	4.9E-05	6-7a	1.5	15	150	47	470	540	5,400	159	150
Long Term Recreator - Adult and Child (14 days per year; 2 years as child, 24 years as adult)	C	7.39E+01	6.2E-04	6-8a	0.12	1.2	12	47	470	540	5,400	159	12

Notes:

The rbAL soil units are pCi/g.

The rbALs were back-calculated from the radium cancer risks (shown to two significant figures) for AUM 458, which had the highest relative risk of the evaluated areas.

Ra-226 rbAL values include daughter products.

The "Long Term Recreator - Adult and Child" receptor group is comparable to the BLM screening receptor scenario.

rbAL values are rounded to two significant digits.

Risk Type: C = cancer risk

Table 8-1b Comparison of Human Health Risk Based Action Levels for Non-Radiological PCOCs in Soils to Comparable Ecological Receptor Risk Based Action Levels

Human Health Receptor and Scenario	PCOCs	Risk Type	AUM 458 HHSRE Risks			Associated HHSRE Table	Human Health rbALs at Different Risk Thresholds				Non-Rad Soil Conc - Wren		Non-Rad Soil Conc - Shrew		Geomean NOAELs	Proposed rbAL
			UCL	HQ	Cancer Risk		1E-06	1E-05	1E-04	HQ=1	$@HQ_{NOAEL}=1$	$@HQ_{LOAEL}=1$	$@HQ_{NOAEL}=1$	$@HQ_{LOAEL}=1$		
Site Workers	Arsenic	C	2.77E+01	---	1.1E-09	6-4a	25,000	250,000	(a)	---	55	120	140	360	87.7	90
	Arsenic, Inorganic	NC	2.77E+01	4.8E-06	---	6-4a	---	---	---	(a)	55	120	140	360	87.7	90
	Mercury (elemental)	NC	1.70E-01	9.4E-08	---	6-4a	---	---	---	(a)	0.25	1.1	1.3	NC	0.57	0.6
	Molybdenum	NC	3.50E+02	5.0E-06	---	6-4a	---	---	---	(a)	1,400	NC	37	120	228	230
	Selenium	NC	5.18E-01	7.5E-09	---	6-4a	---	---	---	(a)	3.2	7.6	4.3	9.1	3.71	4
	Uranium (Soluble Salts)	NC	8.62E+01	3.1E-05	---	6-4a	---	---	---	(a)	5,700	57,000	450	NC	1,602	360
	Vanadium and Compounds	NC	1.76E+01	2.5E-07	---	6-4a	---	---	---	(a)	77	160	110	220	92.0	92
Long-Term Recreator - Adult Only (14 days per year, 24 years)	Arsenic	C	2.77E+01	---	5.0E-07	6-5a	56	560	5,600	---	55	120	140	360	87.7	90
	Arsenic, Inorganic	NC	2.77E+01	3.2E-03	---	6-5a	---	---	---	8,600	55	120	140	360	87.7	90
	Mercury (elemental)	NC	1.70E-01	1.9E-04	---	6-5a	---	---	---	910	0.25	1.1	1.3	NC	0.57	0.6
	Molybdenum	NC	3.50E+02	3.4E-03	---	6-5a	---	---	---	100,000	1,400	NC	37	120	228	230
	Selenium	NC	5.18E-01	5.0E-06	---	6-5a	---	---	---	100,000	3.2	7.6	4.3	9.1	3.71	4
	Uranium (Soluble Salts)	NC	8.62E+01	2.1E-02	---	6-5a	---	---	---	4,200	5,700	57,000	450	NC	1,602	360
	Vanadium and Compounds	NC	1.76E+01	1.7E-04	---	6-5a	---	---	---	100,000	77	160	110	220	92.0	92
Long-Term Recreator - Child Only (14 days per year; 2 years as child)	Arsenic	C	2.77E+01	---	4.1E-07	6-6a	68	680	6,800	---	55	120	140	360	87.7	90
	Arsenic, Inorganic	NC	2.77E+01	3.2E-02	---	6-6a	---	---	---	870	55	120	140	360	87.7	90
	Mercury (elemental)	NC	1.70E-01	1.9E-04	---	6-6a	---	---	---	910	0.25	1.1	1.3	NC	0.57	0.6
	Molybdenum	NC	3.50E+02	3.6E-02	---	6-6a	---	---	---	9,800	1,400	NC	37	120	228	230
	Selenium	NC	5.18E-01	5.3E-05	---	6-6a	---	---	---	9,800	3.2	7.6	4.3	9.1	3.71	4
	Uranium (Soluble Salts)	NC	8.62E+01	2.2E-01	---	6-6a	---	---	---	390	5,700	57,000	450	NC	1,602	360
	Vanadium and Compounds	NC	1.76E+01	1.8E-03	---	6-6a	---	---	---	9,800	77	160	110	220	92.0	92
Long-Term Recreator - Adult and Child (14 days per year; 2 years as child, 24 years as adult)	Arsenic	C	2.77E+01	---	9.0E-07	6-7a	31	310	3,100	---	55	120	140	360	87.7	90
	Arsenic, Inorganic	NC	2.77E+01	3.5E-02	---	6-7a	---	---	---	790	55	120	140	360	87.7	90
	Mercury (elemental)	NC	1.70E-01	3.7E-04	---	6-7a	---	---	---	450	0.25	1.1	1.3	NC	0.57	0.6
	Molybdenum	NC	3.50E+02	3.9E-02	---	6-7a	---	---	---	8,900	1,400	NC	37	120	228	230
	Selenium	NC	5.18E-01	5.8E-05	---	6-7a	---	---	---	8,900	3.2	7.6	4.3	9.1	3.71	4
	Uranium (Soluble Salts)	NC	8.62E+01	2.4E-01	---	6-7a	---	---	---	360	5,700	57,000	450	NC	1,602	360
	Vanadium and Compounds	NC	1.76E+01	2.0E-03	---	6-7a	---	---	---	9,000	77	160	110	220	92.0	92

Notes:

The rbAL soil units are mg/kg_{dw}.

The rbALs were back-calculated from the risks for AUM 458, which had the highest relative risk of the evaluated areas.

The "Long-Term Recreator - Adult and Child" receptor group is comparable to the BLM screening receptor scenario.

Risk Type: C = cancer risk, NC = non-cancer

NC = Not calculated. TRV_{LOAEL} was not available for molybdenum in this speces.

rbAL values are rounded to two significant digits.

(a) rbAL value exceeds 1,000,000 mg/kg.

Table 9-1 Potential Pit Capacities

Cover Option	AUM 457 (CY)	AUM 458 (CY)
Channel Cover	1,340	740
Mound Cover	1,560	800
Raised Mound Cover	NA	5,670

Table 9-2 Horizonal Correlations Between Exposure Rate and Static Gamma Count Rate

HORIZONTAL CORRELATION				
Pool	Background pCi/g	IL pCi/g	gamma - mean cpm(1)	gamma - 95 LPL cpm
Drainage	1.71	2.95	48419	19004
Alluvial	3.72	4.96	67169	37096
LCR	1.26	2.5	44221	14953

Notes:

[1]The gamma measurement for the horizontal correlation was a scanning measurement performed using an unshielded 3-inch by 3-inch NaI(Tl) detector

Table 9-3 Vertical Correlations Between Exposure Rate and Ra-266 Concentrations in Soil

VERTICAL CORRELATION				
Pool	Background pCi/g	IL pCi/g	**NET** gamma - mean cpm(1,2)	**NET** gamma - 95 LPL cpm
Drainage	1.71	2.95	1828	-941
Alluvial	3.72	4.96	2307	-458
LCR	1.26	2.5	1721	-1049

Notes:

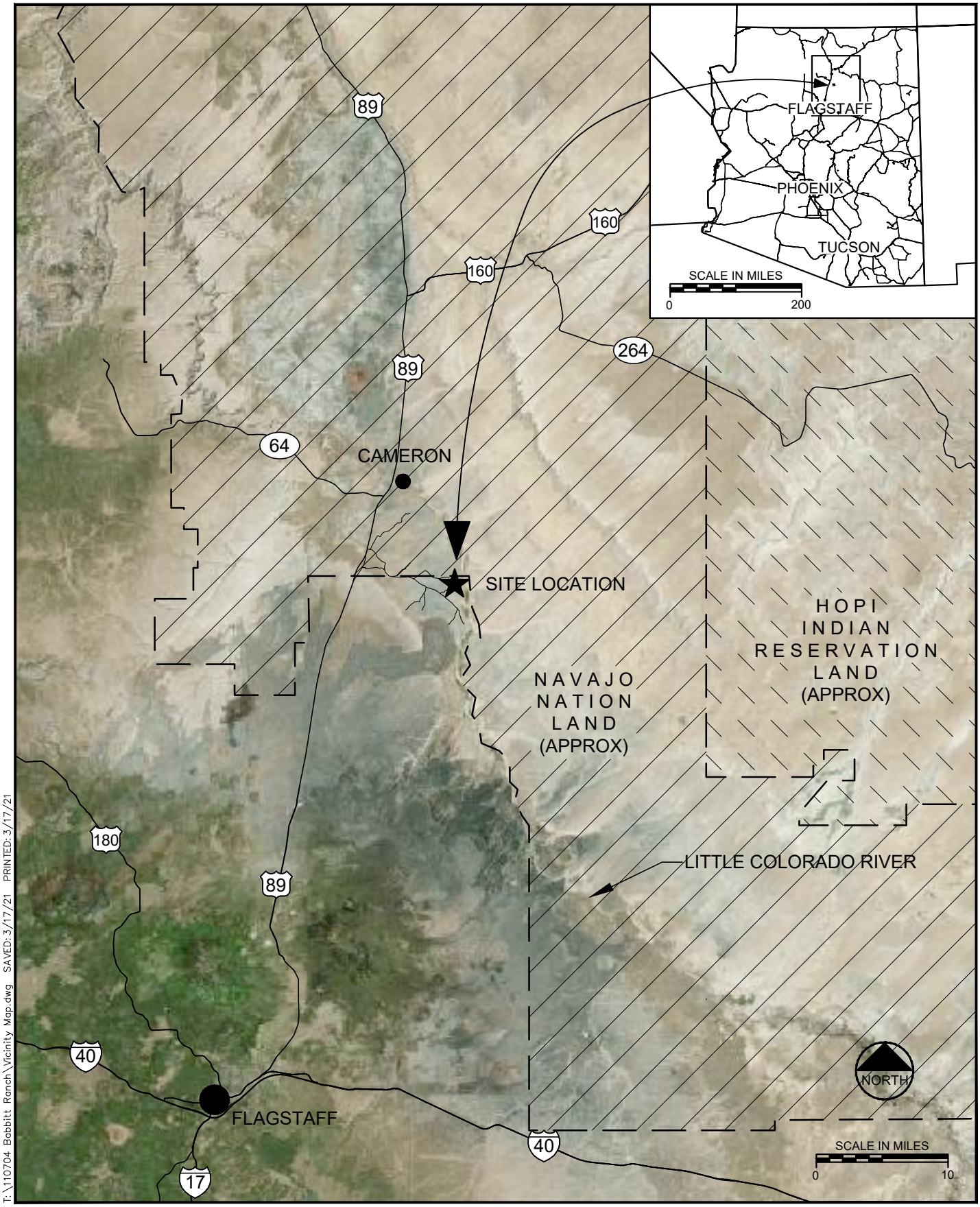
[1]The gamma measurement for the vertical correlation was a static measurement performed using a shielded 2-inch by 2-inch NaI(Tl) detector
[2]The second correlation data set (n=41) regression was used to develop the vertical correlation

Table 9-4 Waste Volumes

Quadrant	Volume Above IL[(1)] (CY)	Volume Above 160 pCi/g[(2)] (CY)	Volume Above 12 pCi/g[(3)] (CY)
NW	4,087	0	1,166
NE	10,209	0	2,688
SW	7,818	940	5,535
SE	9,436	2	647
TOTAL	**31,550**	**942**	**10,036**

Notes: [1] Investigation Level (IL) for Ra-226 is 1.24 above background as presented in Table 9-2.
(Drainage = 2.95 pCi/g, Alluvial = 4.96 pCi/g, LCR = 2.5 pCi/g) and presented on Figures 9-9 through 9-15.
[2] Risk Based Action Level (rbAL) for On-Site Worker (Section 8.0; Table 8-1a)
[3] rbAL for Long Term Adult Recreator and Child (Section 8.0; Table 8.1a)

FIGURES



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Project No. 110704

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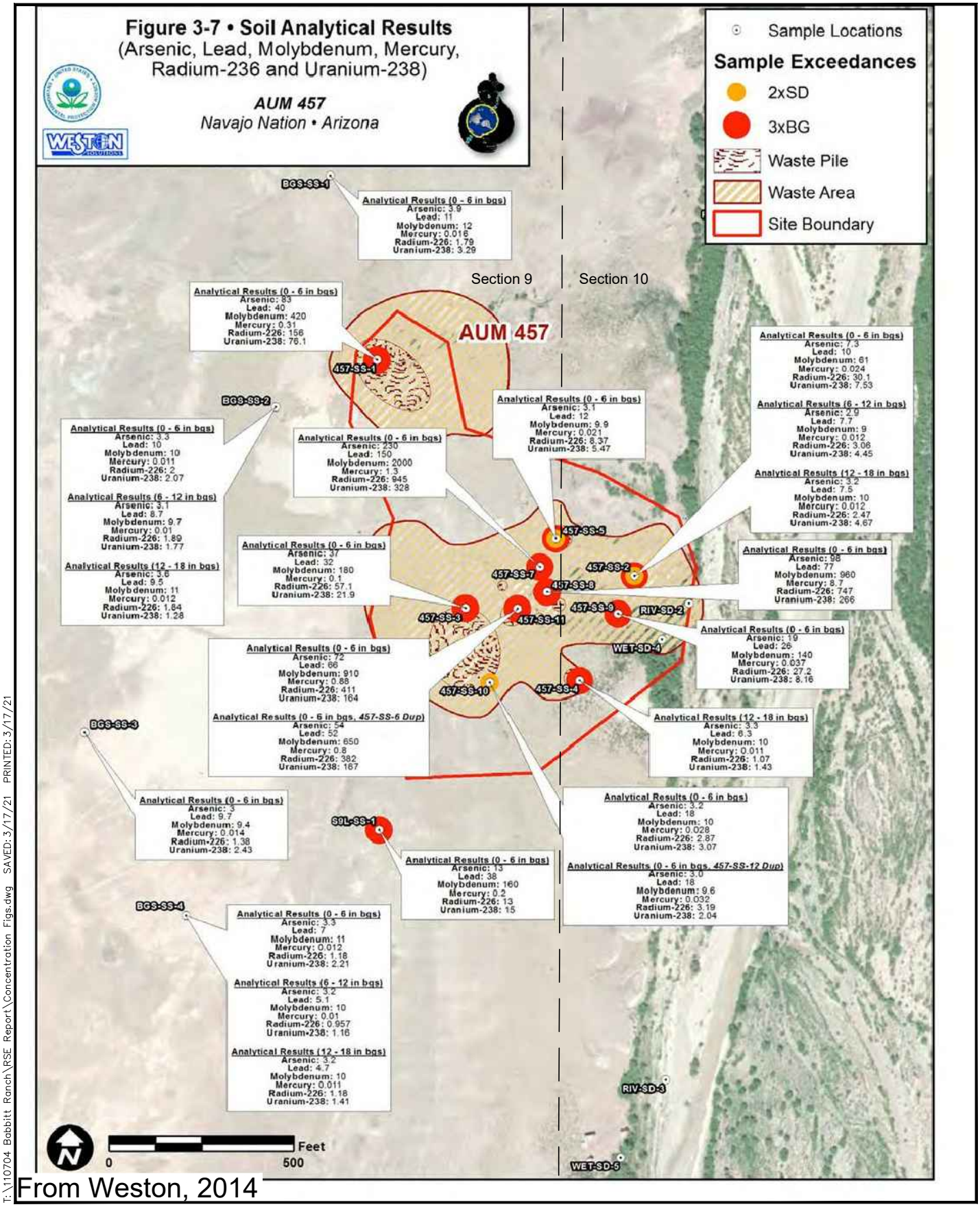
FIGURE 1-1
SITE LOCATION
BABBITT RANCHES



From Weston, 2014

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Project No. 110704

Note: Metal Concentration in mg/kg
Radionuclide Concentration in pCi/g

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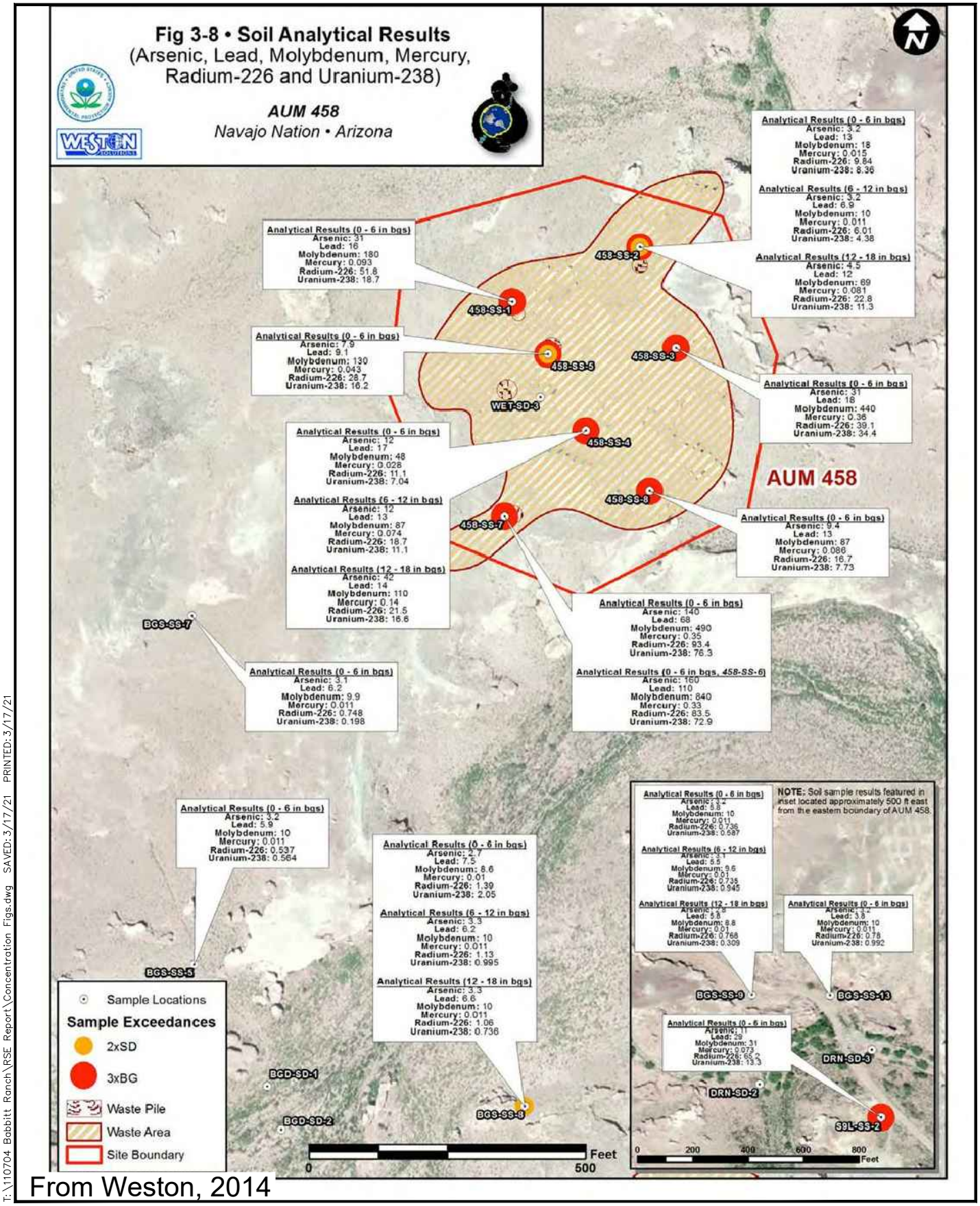
FIGURE 1-2
AUM 457 PCOC SOILS CONCENTRATIONS
BABBITT RANCHES



From Weston, 2014

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Project No. 110704

Note: Metal Concentration in mg/kg
Radionuclide Concentration in pCi/g

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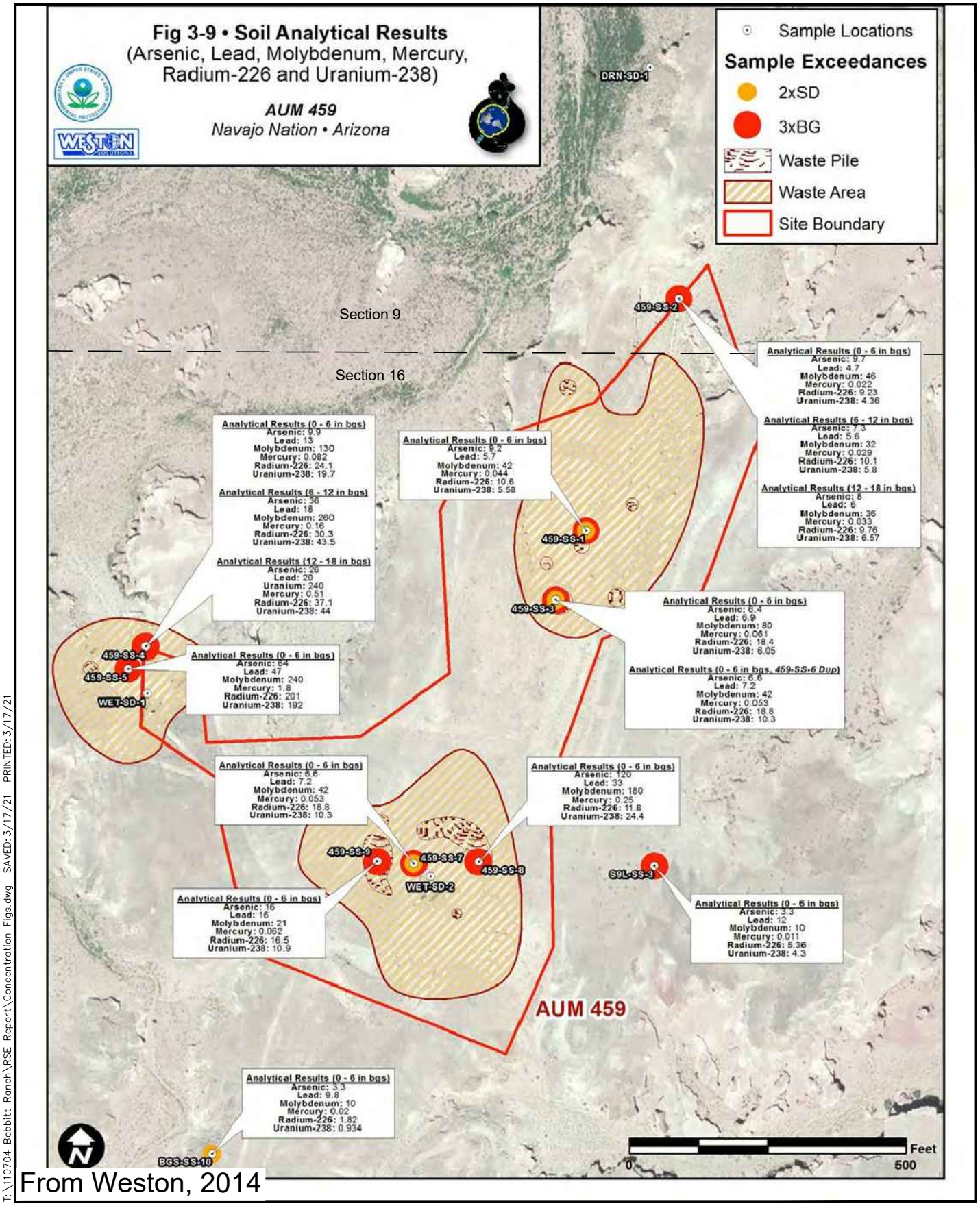
FIGURE 1-3
AUM 458 PCOC SOILS CONCENTRATIONS
BABBITT RANCHES



From Weston, 2014

T:\110704 Babbitt Ranch\RSE Report\Concentration Figs.dwg SAVED: 3/17/21 PRINTED: 3/17/21

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Note: Metal Concentration in mg/kg
Radionuclide Concentration in pCi/g

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FIGURE 1-4
AUM 459 PCOC SOILS CONCENTRATIONS
BABBITT RANCHES

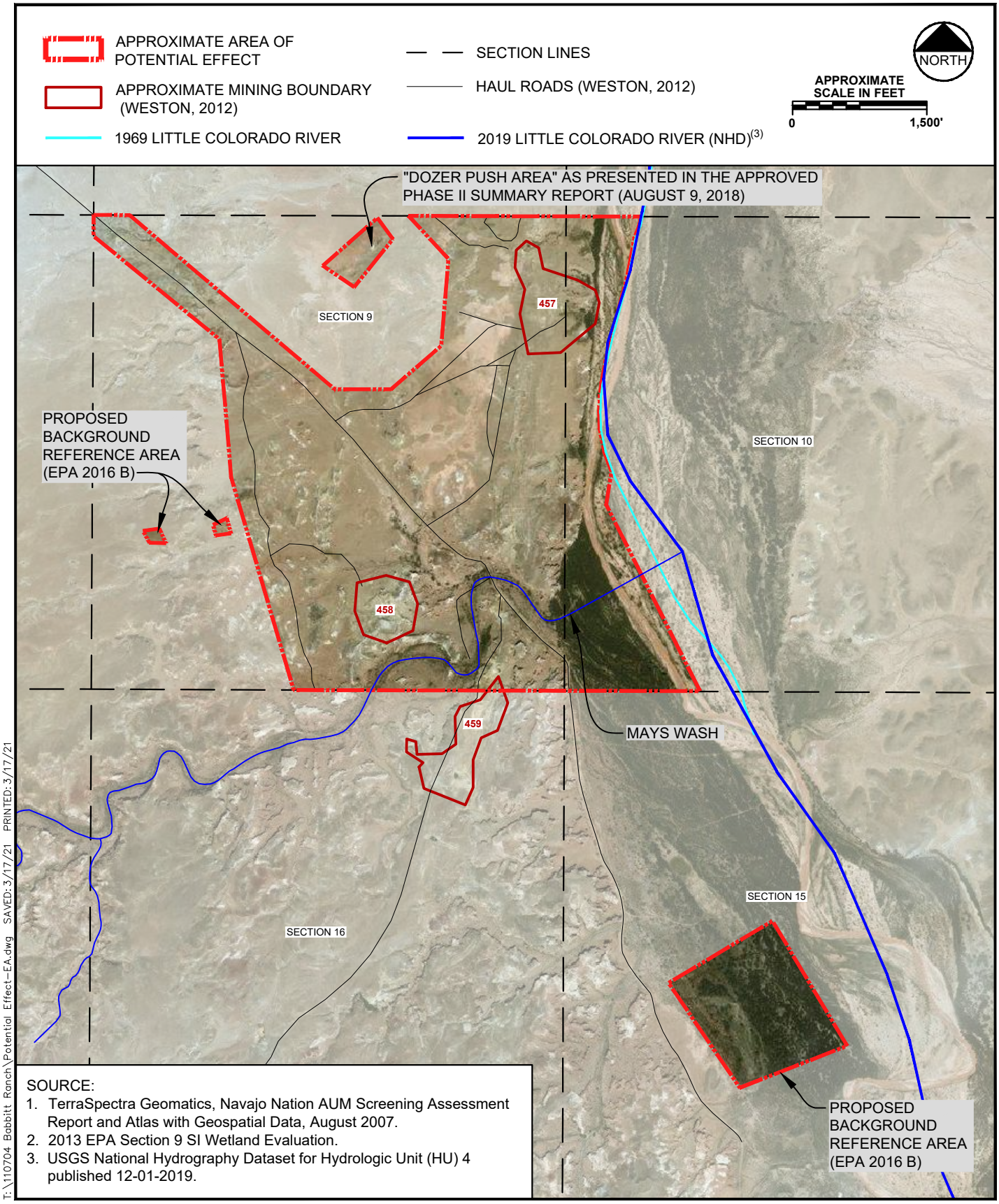

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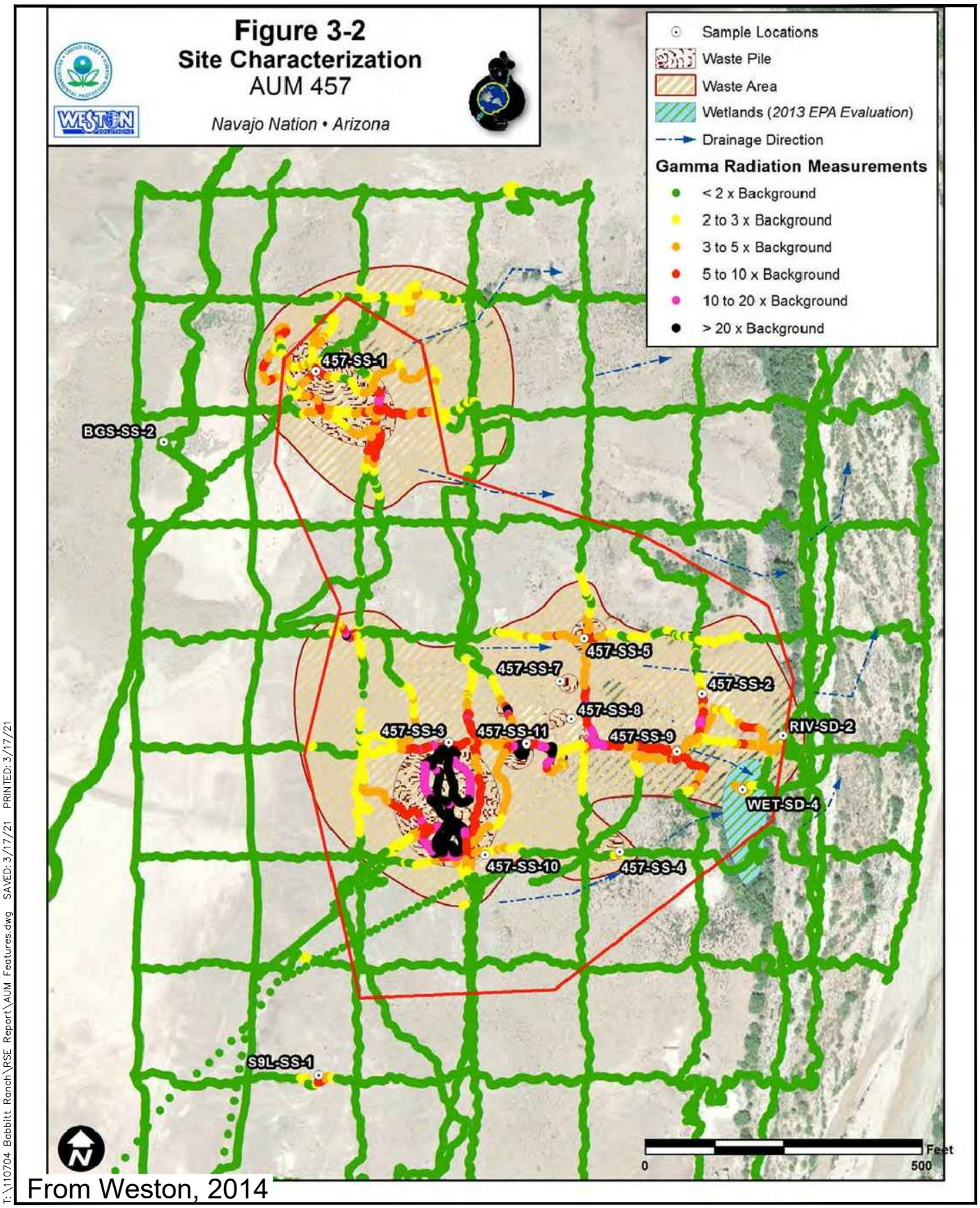
FIGURE 2-1
SITE LOCATION AND PROPOSED AREA OF POTENTIAL EFFECT FOR PHASE III WORK
BABBITT RANCHES



From Weston, 2014

T:\110704 Babbitt Ranch\RSE Report\AUM Features.dwg SAVED: 3/17/21 PRINTED: 3/17/21

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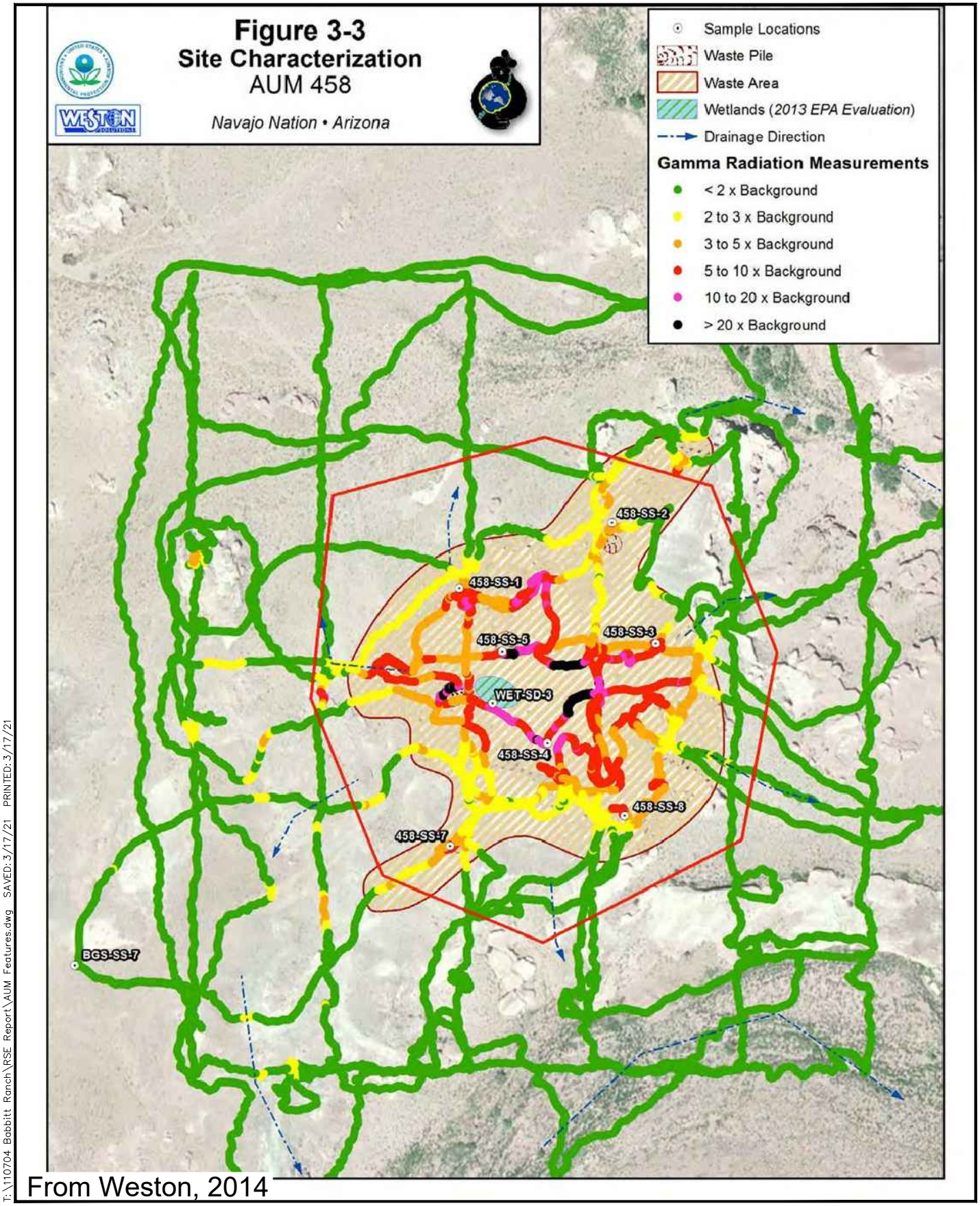
FIGURE 2-2
WESTON GAMMA SURVEY DATA, AUM 457
BABBITT RANCHES



From Weston, 2014

T:\110704 Babbitt Ranch\RSE Report\AUM Features.dwg SAVED: 3/17/21 PRINTED: 3/17/21

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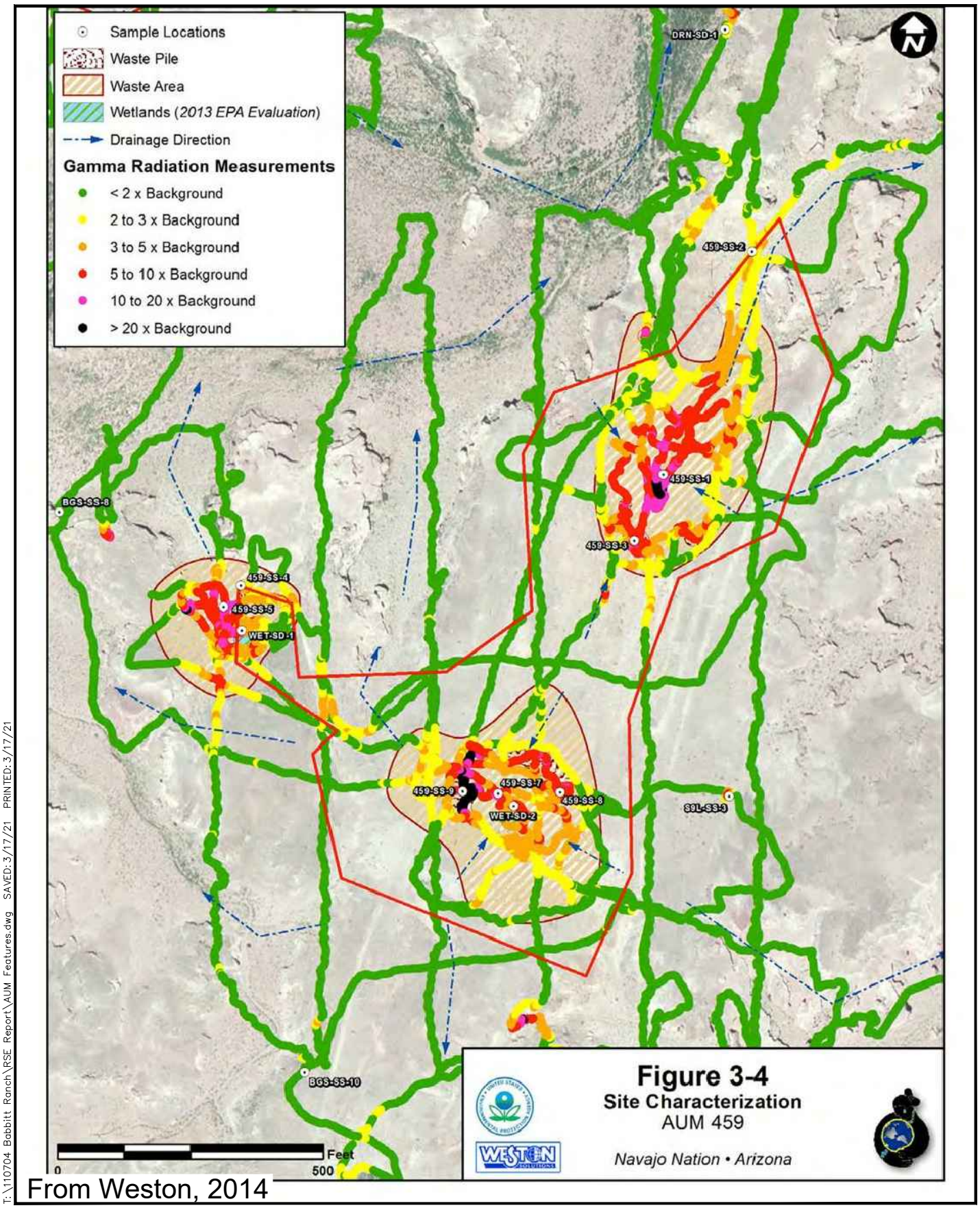
FIGURE 2-3
WESTON GAMMA SURVEY DATA, AUM 458
BABBITT RANCHES



From Weston, 2014

T:\110704 Babbitt Ranch\RSE Report\AUM Features.dwg SAVED: 3/17/21 PRINTED: 3/17/21

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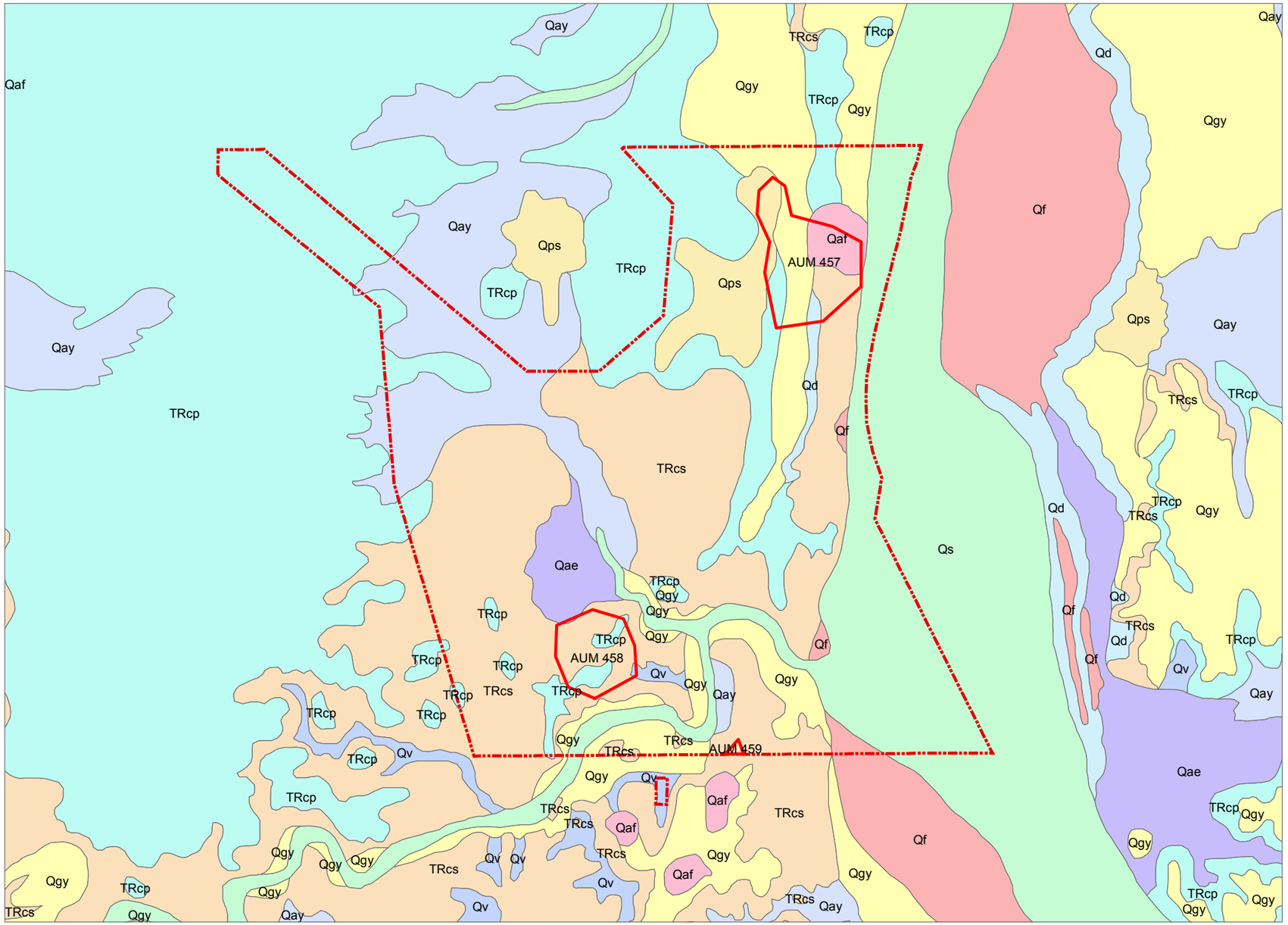
FIGURE 2-4
WESTON GAMMA SURVEY DATA, AUM 459
BABBITT RANCHES



EXPLANATION

- EPA AUM Boundary
- Area of Potential Effect

Geologic Units

- Qae Alluvial/Eolian Deposit
- Qaf Artificial Fill
- Qay Alluvial Fan Deposit
- Qd Dune Sand
- Qf Floodplain Deposit
- Qgy Terrace Deposit
- Qps Ponded Sediments
- Qs Stream Channel Deposits
- Qv Valley Fill
- TRcp Petrified Forest Member
- TRcs Shinarump Member

N

0 500 1,000 2,000

Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 2-5 Geology.mxd Date Saved: March, 17, 2021

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FIGURE 2-5
SITE GEOLOGY (BILLINGSLEY ET AL., 2007)
BABBITT RANCHES

T:\110704 Babbitt Ranch\RSE Report\AUM Features.dwg SAVED: 3/17/21 PRINTED: 3/17/21

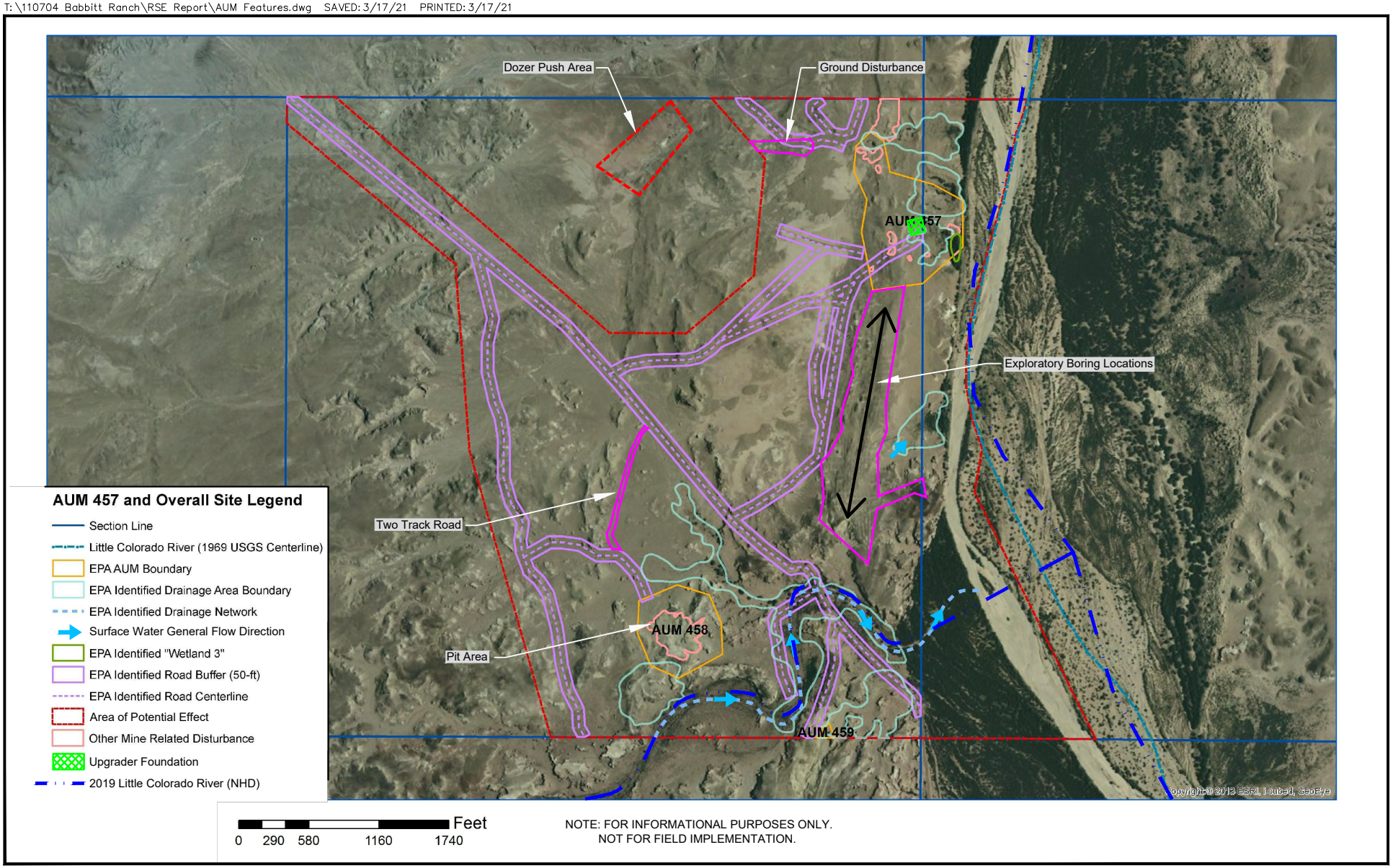

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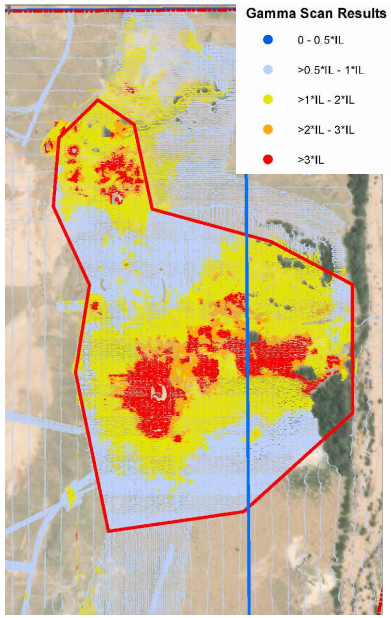
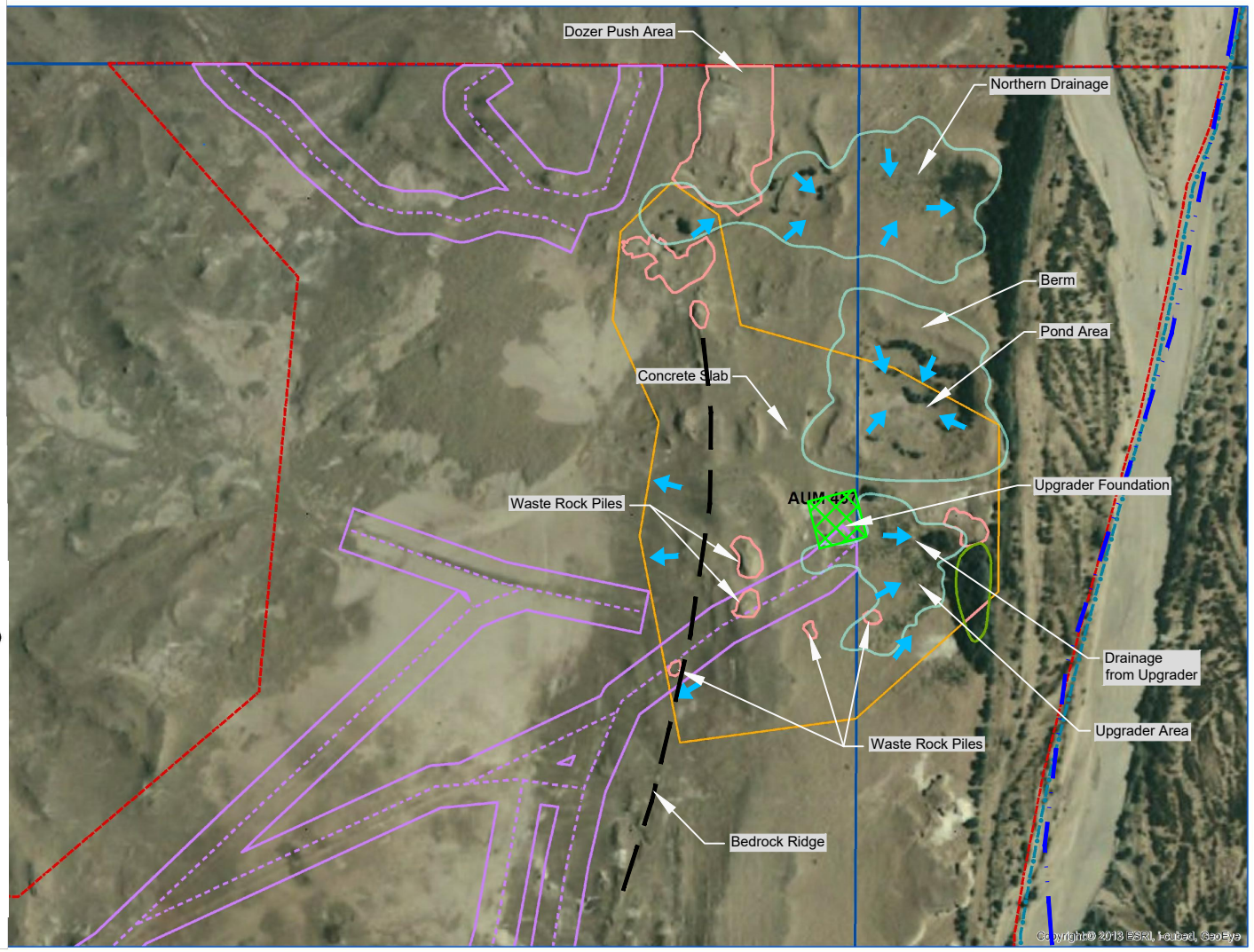
FIGURE 2-6
PHYSICAL CONCEPTUAL SITE MODEL
FOR THE AREA OF POTENTIAL EFFECT
BABBITT RANCHES

T:\110704 Babbitt Ranch\RSE Report\AUM Features.dwg SAVED: 3/17/21 PRINTED: 3/17/21





LEGEND:

- Section Line
- Little Colorado River (1969 USGS Centerline)
- EPA AUM Boundary
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- EPA Identified "Wetland 3"
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline
- Area of Potential Effect
- Other Mine Related Disturbance
- Upgrader Foundation
- Surface Water General Flow Direction
- 2019 Little Colorado River (NHD)

0 100 200 400 600 Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY.
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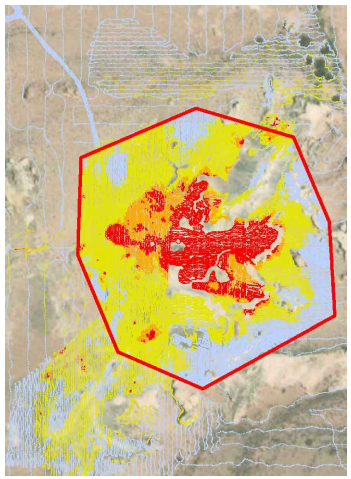
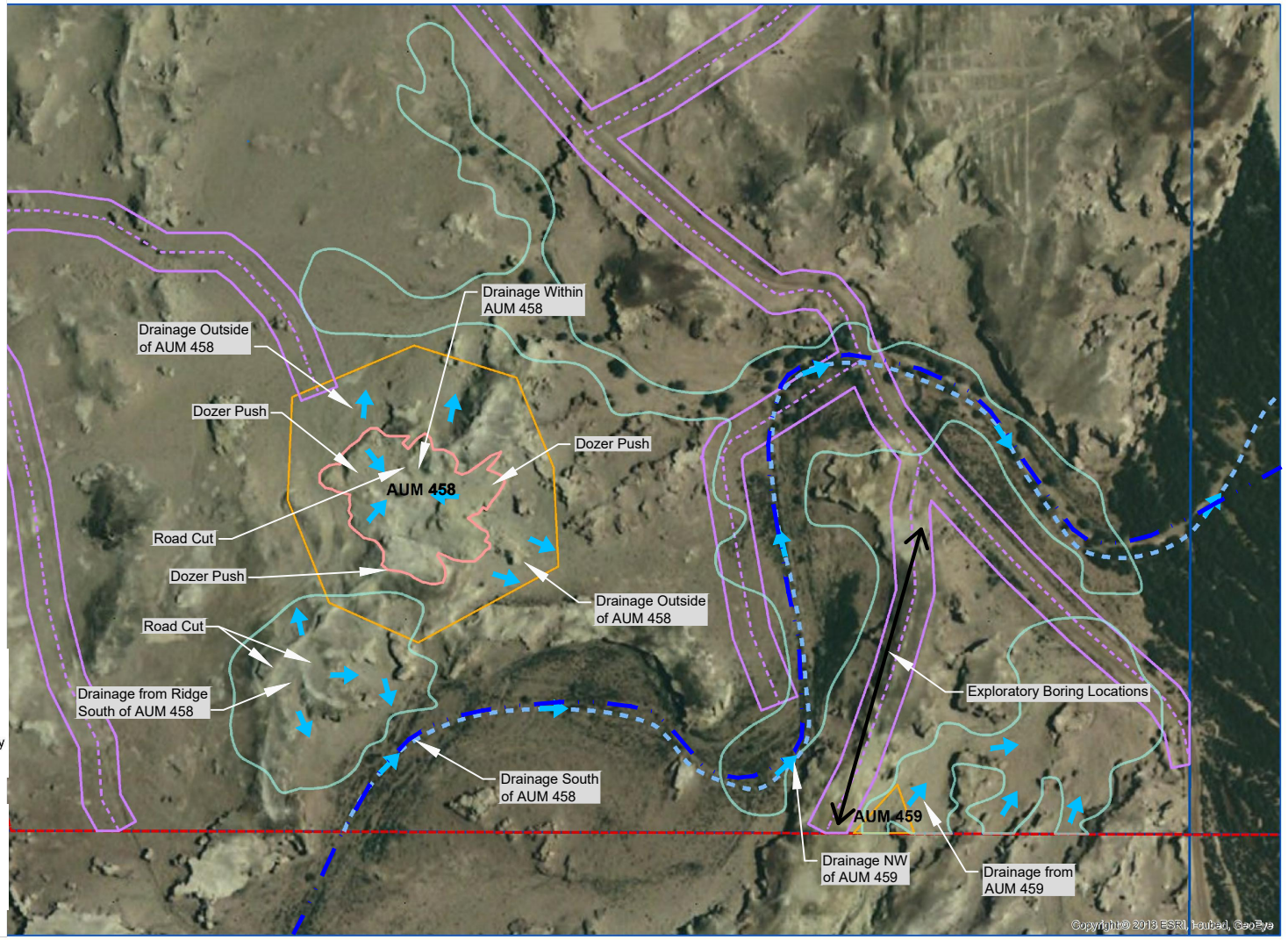
FIGURE 2-7
PHYSICAL CONCEPTUAL SITE MODEL FOR AUM 457
BABBITT RANCHES

T:\110704 Babbitt Ranch\RSE Report\AUM Features.dwg SAVED: 3/17/21 PRINTED: 3/17/21



Gamma Scan Results
- 0 - 0.5*IL
- >0.5*IL - 1*IL
- >1*IL - 2*IL
- >2*IL - 3*IL
- >3*IL



LEGEND:
- Section Line
- EPA AUM Boundary
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- Surface Water General Flow Direction
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline
- Area of Potential Effects
- Other Mine Related Disturbance
- 2019 Little Colorado River (NHD)

0 110 220 440 660 Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY.
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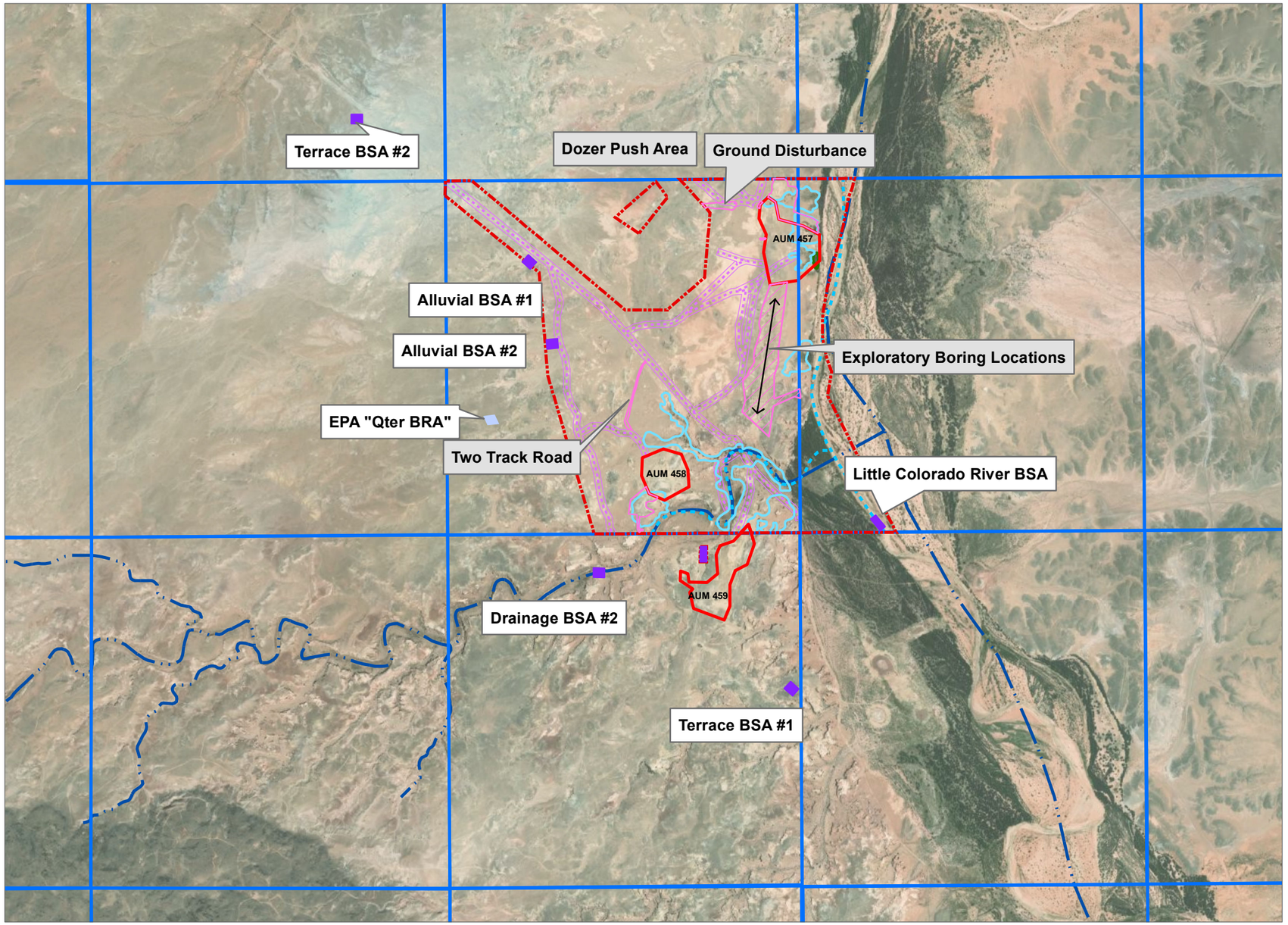
FIGURE 2-8
PHYSICAL CONCEPTUAL SITE MODEL FOR AUMS 458 AND 459
BABBITT RANCHES



LEGEND

- EPA BRA Location
- Babbitt BSA Locations
- Other Mine Related Disturbance
- Other Mine Related Disturbance - Road Scanning
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- 2019 Little Colorado River (NHD)
- EPA Identified "Wetland 3"
- EPA Identified Road Buffer (50-ft)
- EPA Idenfied Road Centerline

N

0 0.175 0.35 0.7
Miles

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mxd\Fig 3-1 BSAs and Disturbance.mxd Date Saved: March 17, 2021

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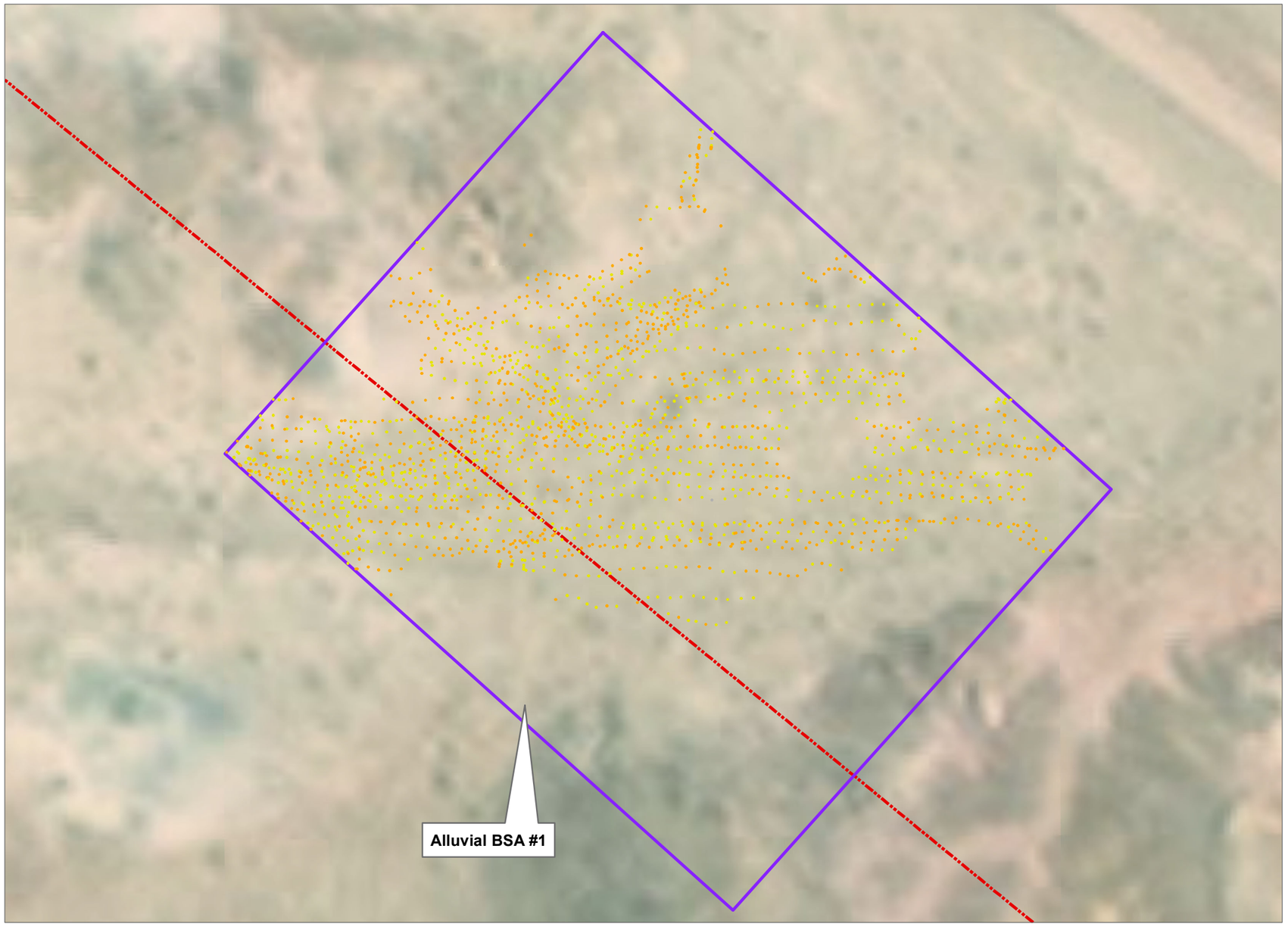
FIGURE 3-1
LOCATIONS OF BSAs AND OTHER MINE RELATED DISTURBANCE
BABBITT RANCHES



LEGEND

- Babbitt BSA Locations
- Area of Potential Effect

Gamma Count Rate

- 0.5 x Mean or Less
- 0.5 x Mean - 0.75 x Mean
- 0.75 x Mean - Mean
- Mean - 1.25 x Mean
- 1.25 x Mean - 1.5 x Mean

NOTE: The mean gamma count for Alluvial BSA #1 is 45,668 cpm.

N

0 15 30 60 Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 4-1 Gamma Alluvial 1.mxd Date Saved: March, 17, 2021

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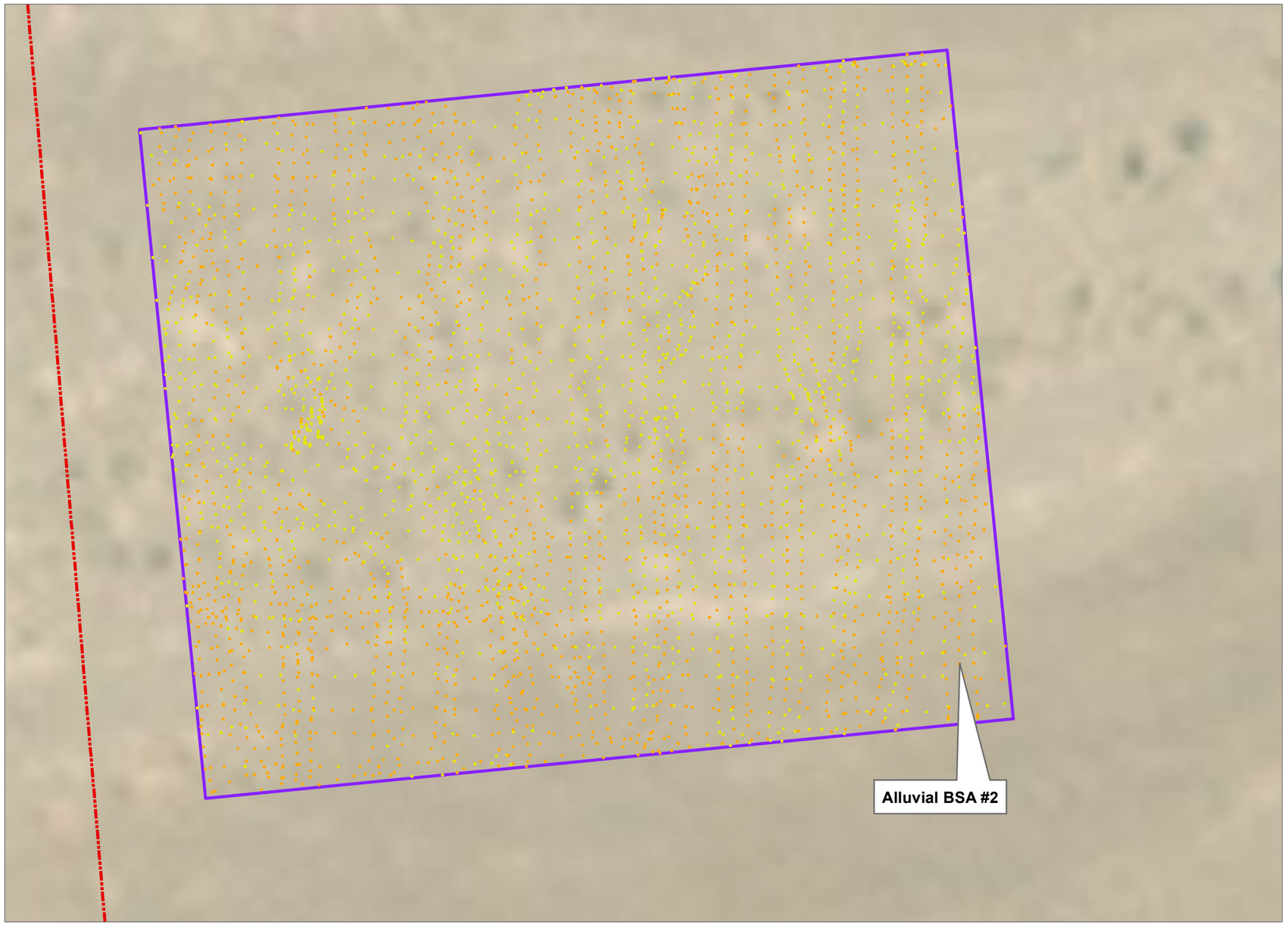
FIGURE 4-1
GAMMA SCAN RESULTS FOR ALLUVIAL BSA #1
BABBITT RANCHES



LEGEND

- Babbitt BSA Locations
- Area of Potential Effect

Gamma Count Rate

- 0.5 x Mean or Less
- 0.5 x Mean - 0.75 x Mean
- 0.75 x Mean - Mean
- Mean - 1.25 x Mean
- 1.25 x Mean - 1.5 x Mean

NOTE: The mean gamma count for Alluvial BSA #2 is 44,771 cpm.

N

0 12.5 25 50 Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 4-2 Gamma Alluvial 2.mxd Date Saved: March, 17, 2021

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FIGURE 4-2
GAMMA SCAN RESULTS FOR ALLUVIAL BSA #2
BABBITT RANCHES

LEGEND

- Babbitt BSA Locations
- Area of Potential Effect

Gamma Count Rate

- 0.5 x Mean or Less
- 0.5 x Mean - 0.75 x Mean
- 0.75 x Mean - Mean
- Mean - 1.25 x Mean
- 1.25 x Mean - 1.5 x Mean

NOTE: The mean gamma count for Drainage BSA #2 is 39,586 cpm.

N

0 12.5 25 50 Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 4-3 Gamma Drainage 2.mxd Date Saved: March. 17, 2021

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FIGURE 4-3
GAMMA SCAN RESULTS FOR DRAINAGE BSA #2
BABBITT RANCHES

LEGEND

- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines

Gamma Count Rate

- 0.5 x Mean or Less
- 0.5 x Mean - 0.75 x Mean
- 0.75 x Mean - Mean
- Mean - 1.25 x Mean
- 1.25 x Mean - 1.5 x Mean

NOTE: The mean gamma count for Terrace BSA #1 is 40,191 cpm.

N

0 15 30 60 Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 4-4 Gamma Terrace 1.mxd Date Saved: March, 17, 2021

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Rev 1.2

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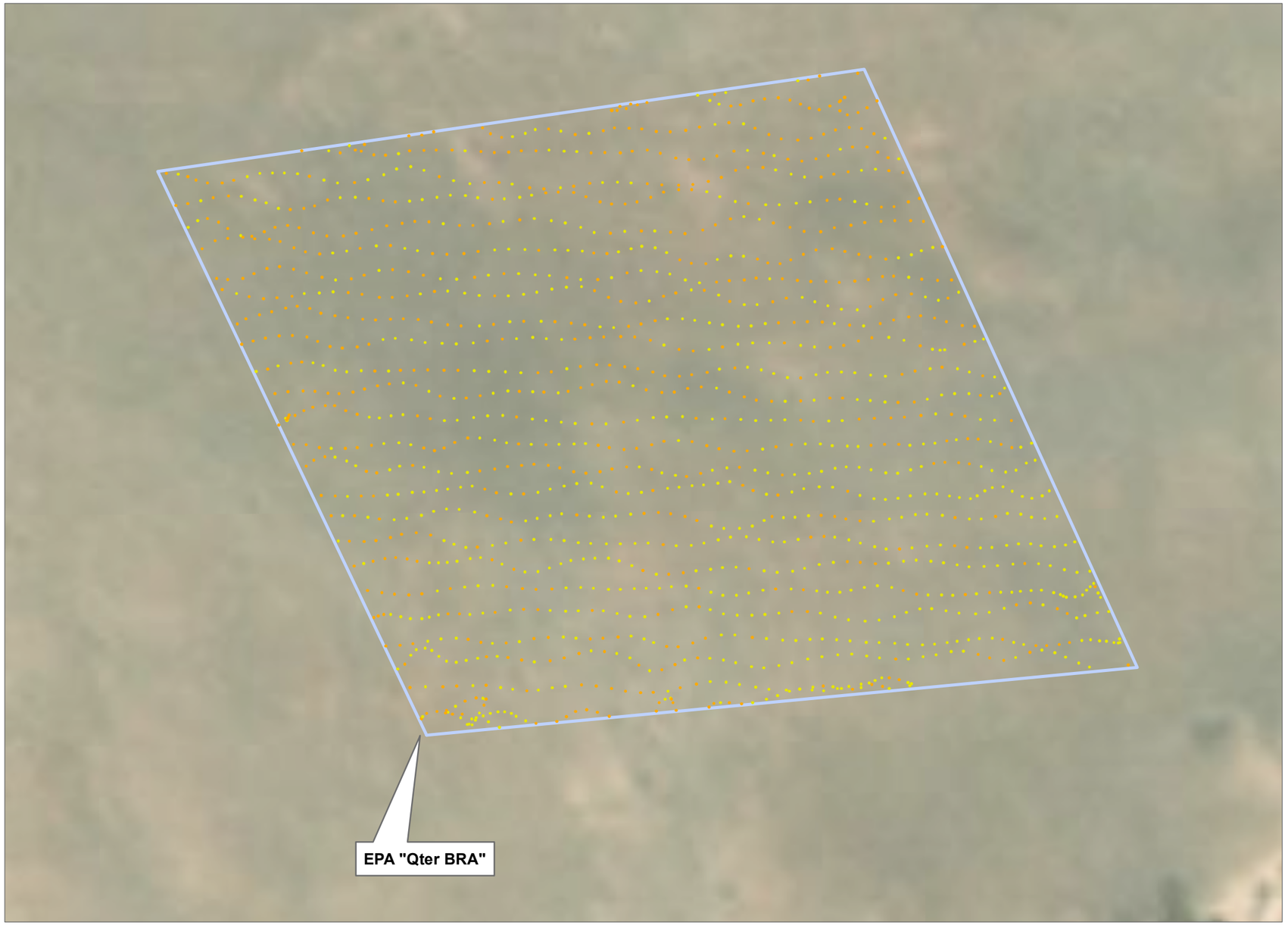
FIGURE 4-4
GAMMA SCAN RESULTS FOR TERRACE BSA #1
BABBITT RANCHES



LEGEND

- EPA BRA Location
- Area of Potential Effect

Gamma Count Rate

- 0.5 x Mean or Less
- 0.5 x Mean - 0.75 x Mean
- 0.75 x Mean - Mean
- Mean - 1.25 x Mean
- 1.25 x Mean - 1.5 x Mean

NOTE: The mean gamma count for EPA Qter BRA is 38,676 cpm.

N

0 15 30 60 Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mxd\Fig 4-5 Gamma EPA QTer.mxd Date Saved: March, 17, 2021

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FIGURE 4-5
GAMMA SCAN RESULTS FOR EPA QTer BRA
BABBITT RANCHES

LEGEND

Babbitt BSA Locations

Area of Potential Effect

Gamma Count Rate

- 0.5 x Mean or Less
- 0.5 x Mean - 0.75 x Mean
- 0.75 x Mean - Mean
- Mean - 1.25 x Mean
- 1.25 x Mean - 1.5 x Mean

NOTE: The mean gamma count for LCR BSA is 23,190 cpm.

N

0 15 30 60

Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 4-6 Gamma LCR.mxd Date Saved: March, 17, 2021

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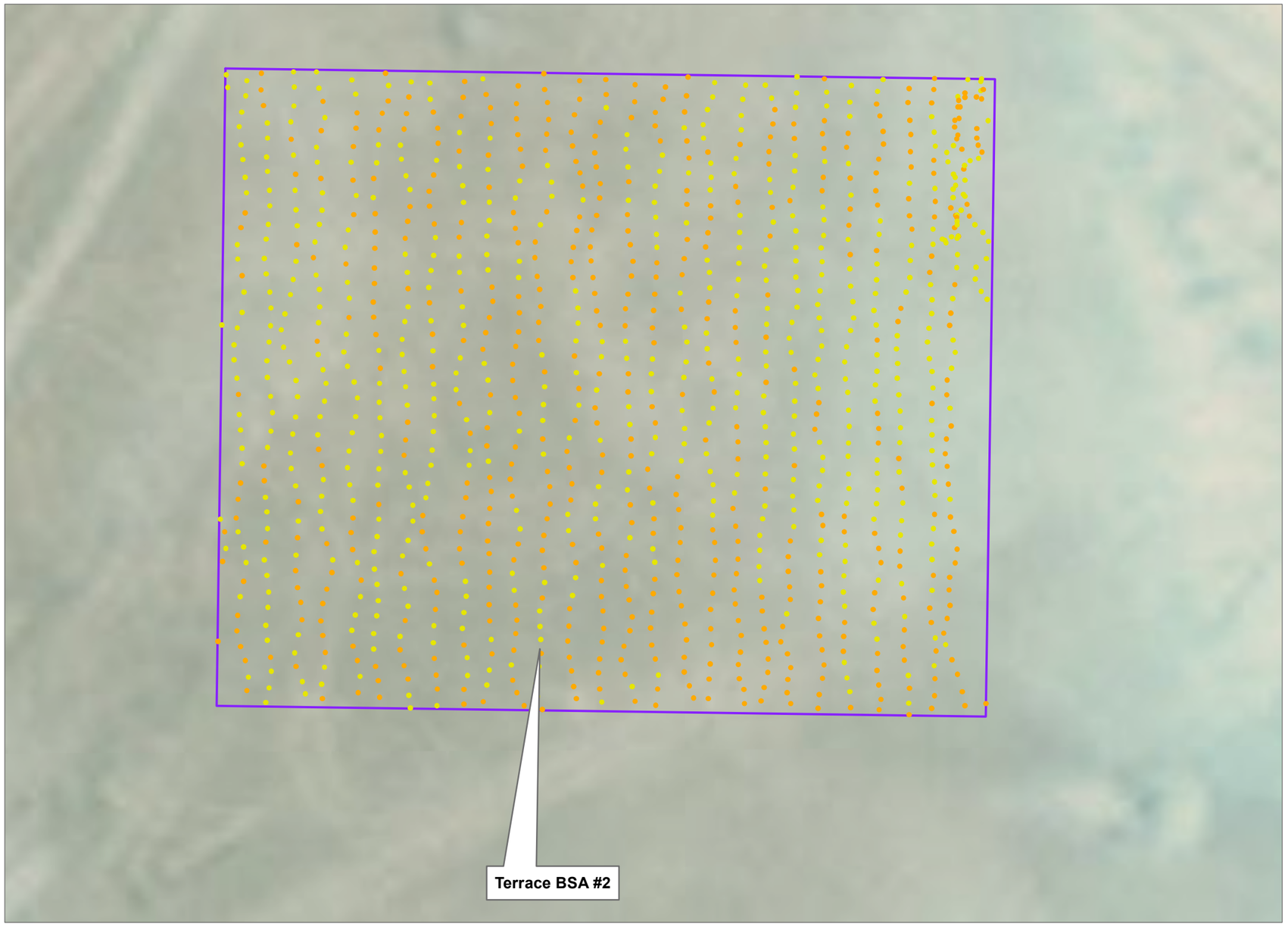
FIGURE 4-6
GAMMA SCAN RESULTS FOR LITTLE COLORADO RIVER BSA
BABBITT RANCHES



LEGEND

Babbitt BSA Locations

Gamma Count Rate

- 0.5 x Mean or Less
- 0.5 x Mean - 0.75 x Mean
- 0.75 x Mean - Mean
- Mean - 1.25 x Mean
- 1.25 x Mean - 1.5 x Mean

NOTE: The mean gamma count for Terrace BSA #2 is 41,106 cpm.

N

0 12.5 25 50

Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mxd\Fig 4-7 Gamma Terrace 2.mxd Date Saved: March, 17, 2021

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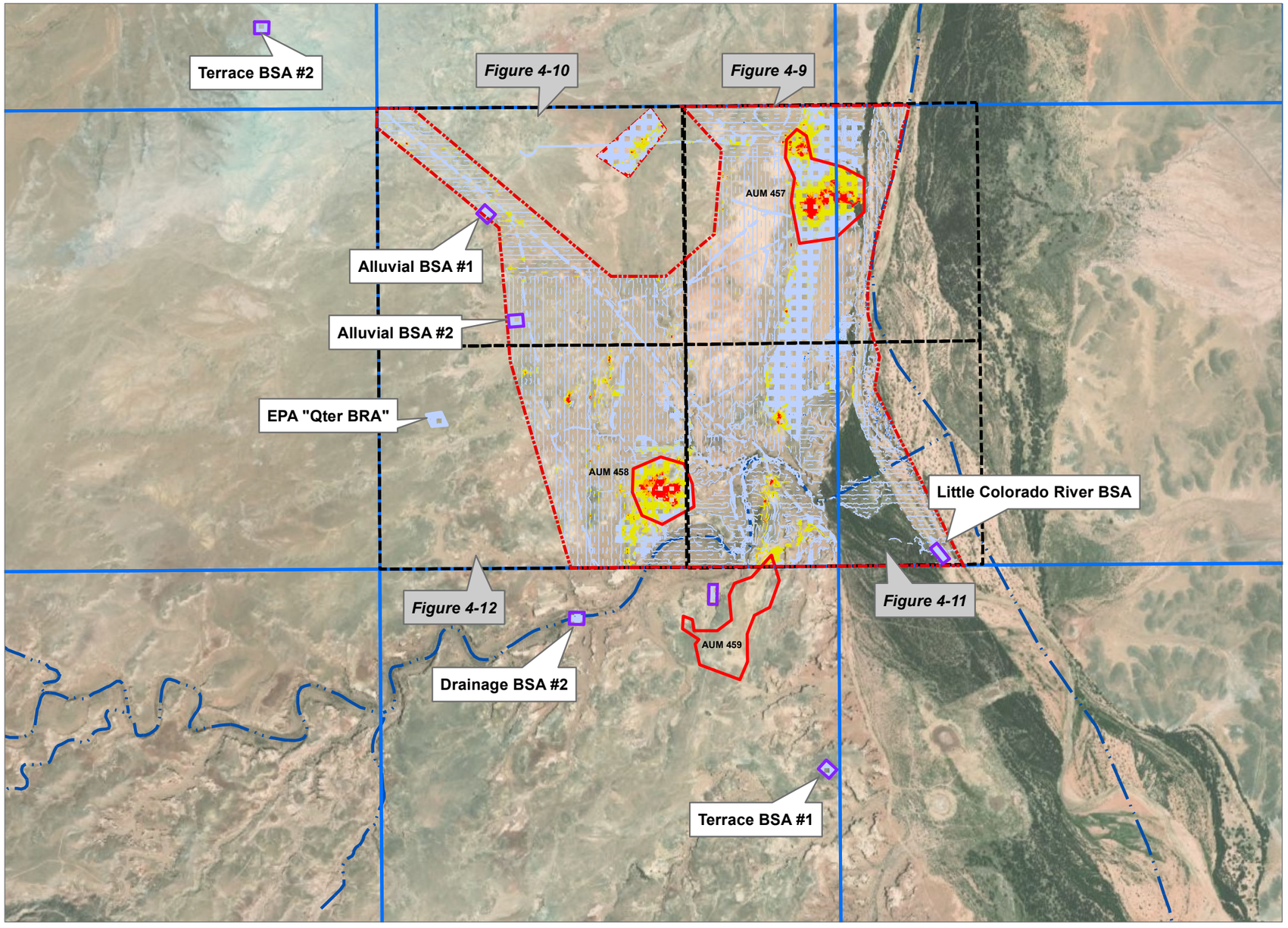
FIGURE 4-7
GAMMA SCAN RESULTS FOR TERRACE BSA #2
BABBITT RANCHES



LEGEND

- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary
- 2019 Little Colorado River (NHD)

Gamma Scan Results

- 0 - 0.5*IL
- >0.5*IL - 1*IL
- >1*IL - 2*IL
- >2*IL - 3*IL
- >3*IL

NOTES:
1) IL Values are provided on Table 5-22.
2) The IL Application Areas are shown on Figure 5-14.

N

0 0.125 0.25 0.5 Miles

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mxd\Fig 4-8 Gamma Scan Results.mxd Date Saved: March. 17, 2021

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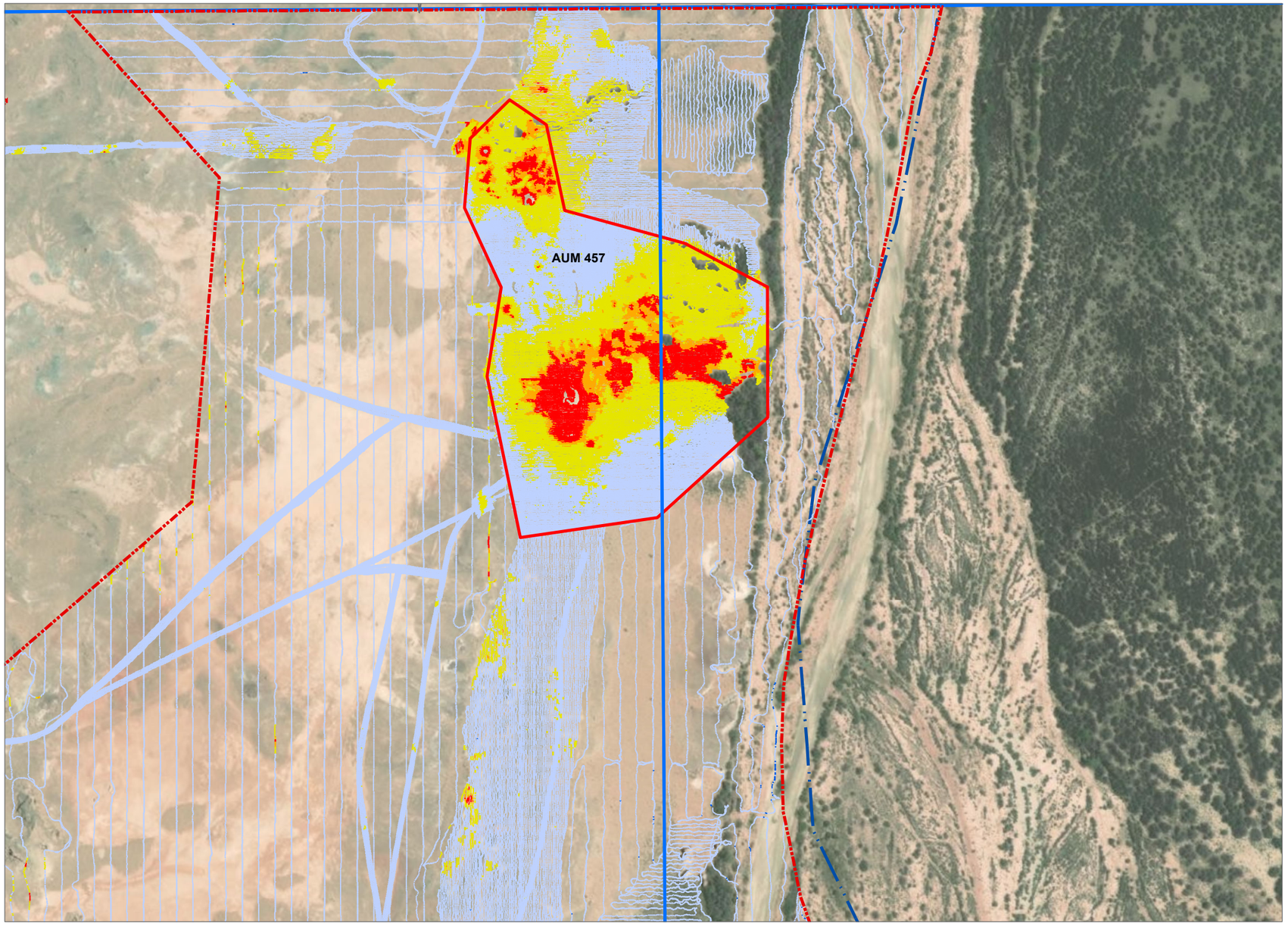
FIGURE 4-8
RESULTS OF MOBILE GAMMA SCAN SURVEY
BABBITT RANCHES



LEGEND

- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary
- 2019 Little Colorado River (NHD)

Gamma Scan Results

- 0 - 0.5*IL
- >0.5*IL - 1*IL
- >1*IL - 2*IL
- >2*IL - 3*IL
- >3*IL

NOTES:
1) IL Values are provided on Table 5-22.
2) The IL Application Areas are shown on Figure 5-14.

N

0 0.0375 0.075 0.15
Miles

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 4-9 Gamma Scan Results - NE.mxd Date Saved: March, 17, 2021

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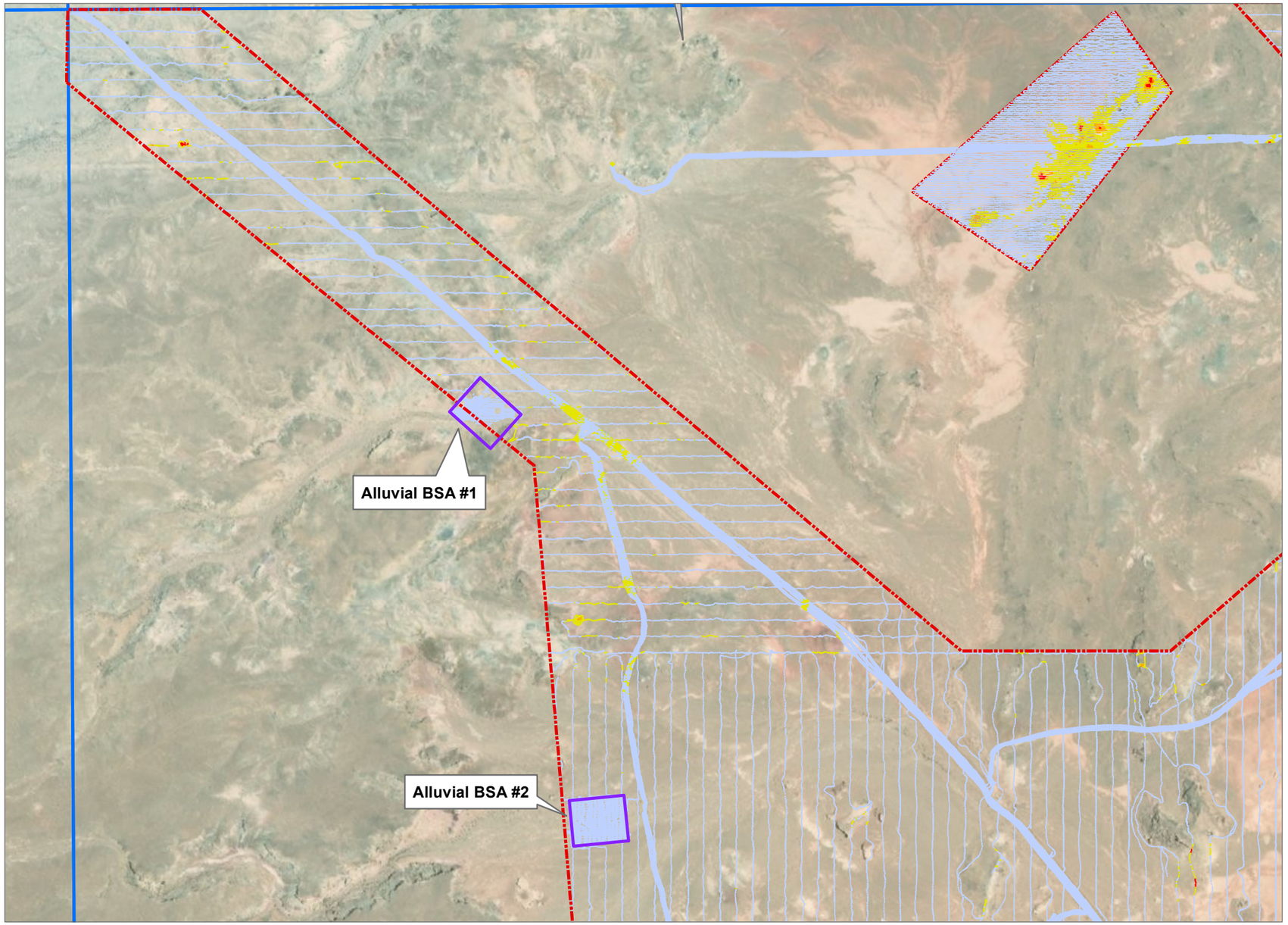
FIGURE 4-9
RESULTS OF MOBILE GAMMA SCAN SURVEY NE QUADRANT
BABBITT RANCHES



LEGEND

- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary

Gamma Scan Results

- 0 - 0.5*IL
- >0.5*IL - 1*IL
- >1*IL - 2*IL
- >2*IL - 3*IL
- >3*IL

NOTES:
1) IL Values are provided on Table 5-22.
2) The IL Application Areas are shown on Figure 5-14.

N

0 0.0375 0.075 0.15
Miles

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 4-10 Gamma Scan Results - NW.mxd Date Saved: March, 17, 2021

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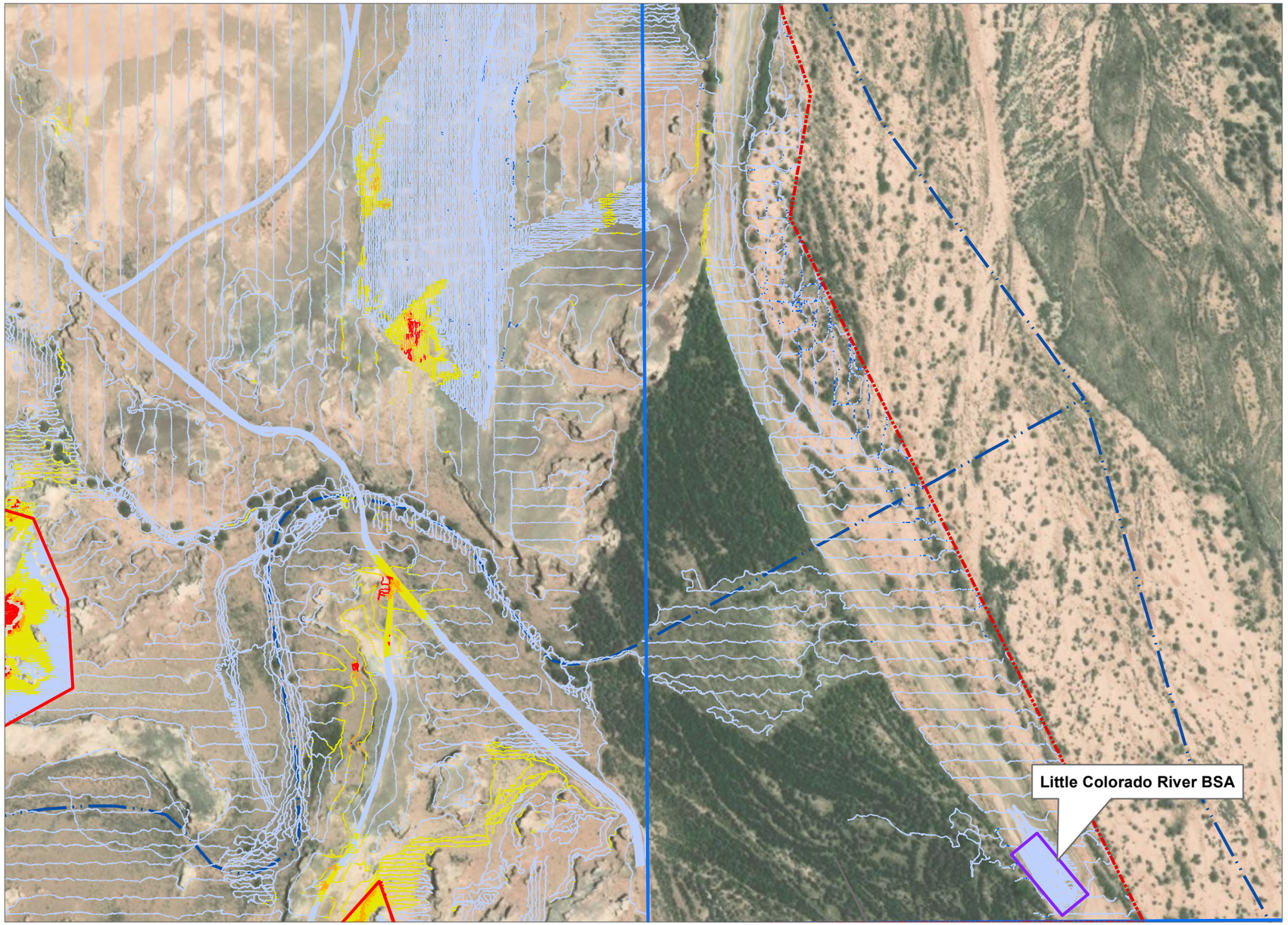
FIGURE 4-10
RESULTS OF MOBILE GAMMA SCAN SURVEY NW QUADRANT
BABBITT RANCHES



LEGEND

- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary
- 2019 Little Colorado River (NHD)

Gamma Scan Results

- 0 - 0.5*IL
- >0.5*IL - 1*IL
- >1*IL - 2*IL
- >2*IL - 3*IL
- >3*IL

NOTES:
1) IL Values are provided on Table 5-22.
2) The IL Application Areas are shown on Figure 5-14.

N

0 0.035 0.07 0.14 Miles

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mxd\Fig 4-11 Gamma Scan Results - SE.mxd Date Saved: March, 17, 2021

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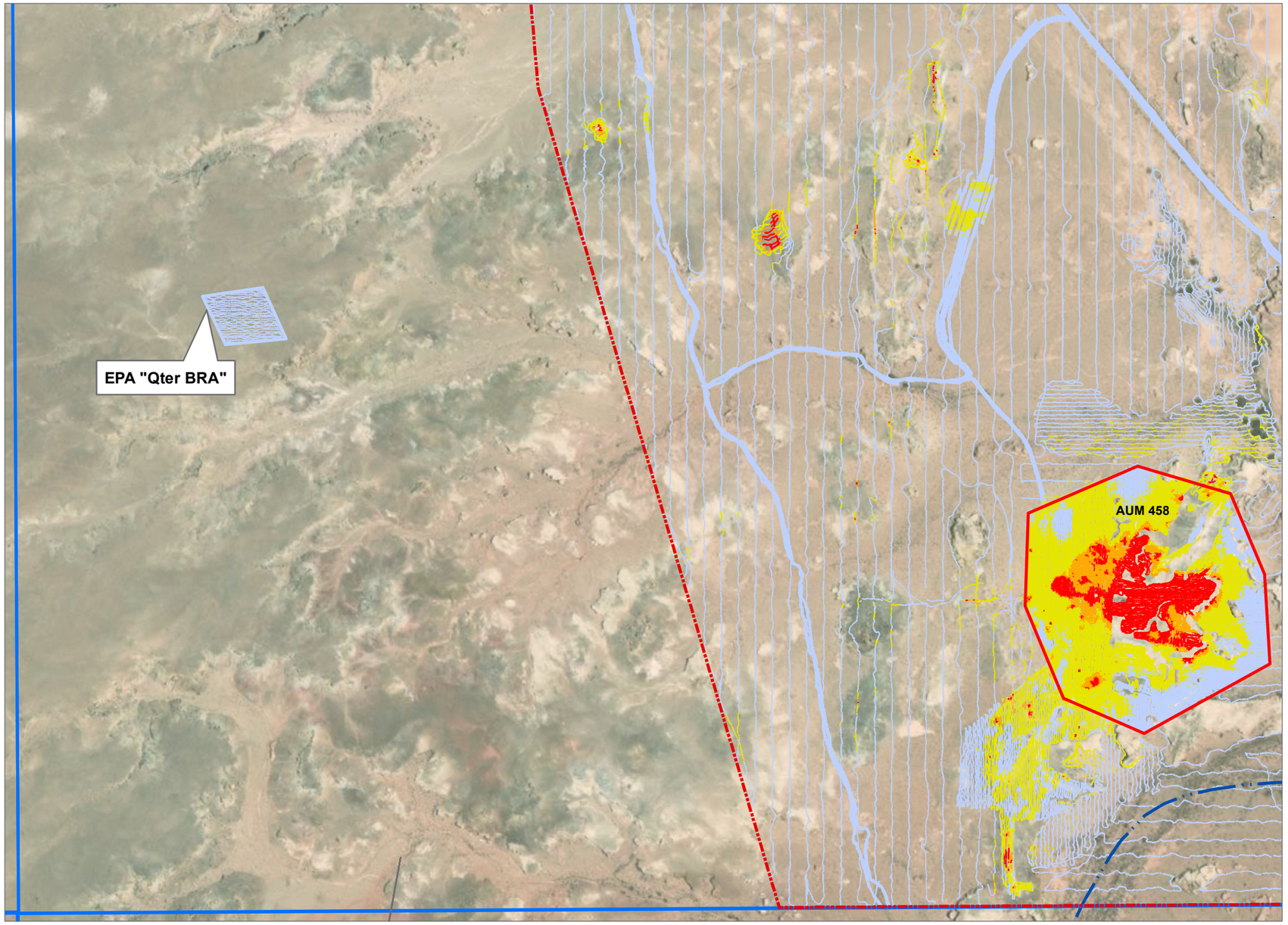
FIGURE 4-11
RESULTS OF MOBILE GAMMA SCAN SURVEY SE QUADRANT
BABBITT RANCHES



LEGEND

- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary
- 2019 Little Colorado River (NHD)

Gamma Scan Results

- 0 - 0.5*IL
- >0.5*IL - 1*IL
- >1*IL - 2*IL
- >2*IL - 3*IL
- >3*IL

NOTES:
1) IL Values are provided on Table 5-22.
2) The IL Application Areas are shown on Figure 5-14.

0 0.035 0.07 0.14 Miles

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mxd\Fig 4-12 Gamma Scan Results - SW.mxd Date Saved: March, 17, 2021

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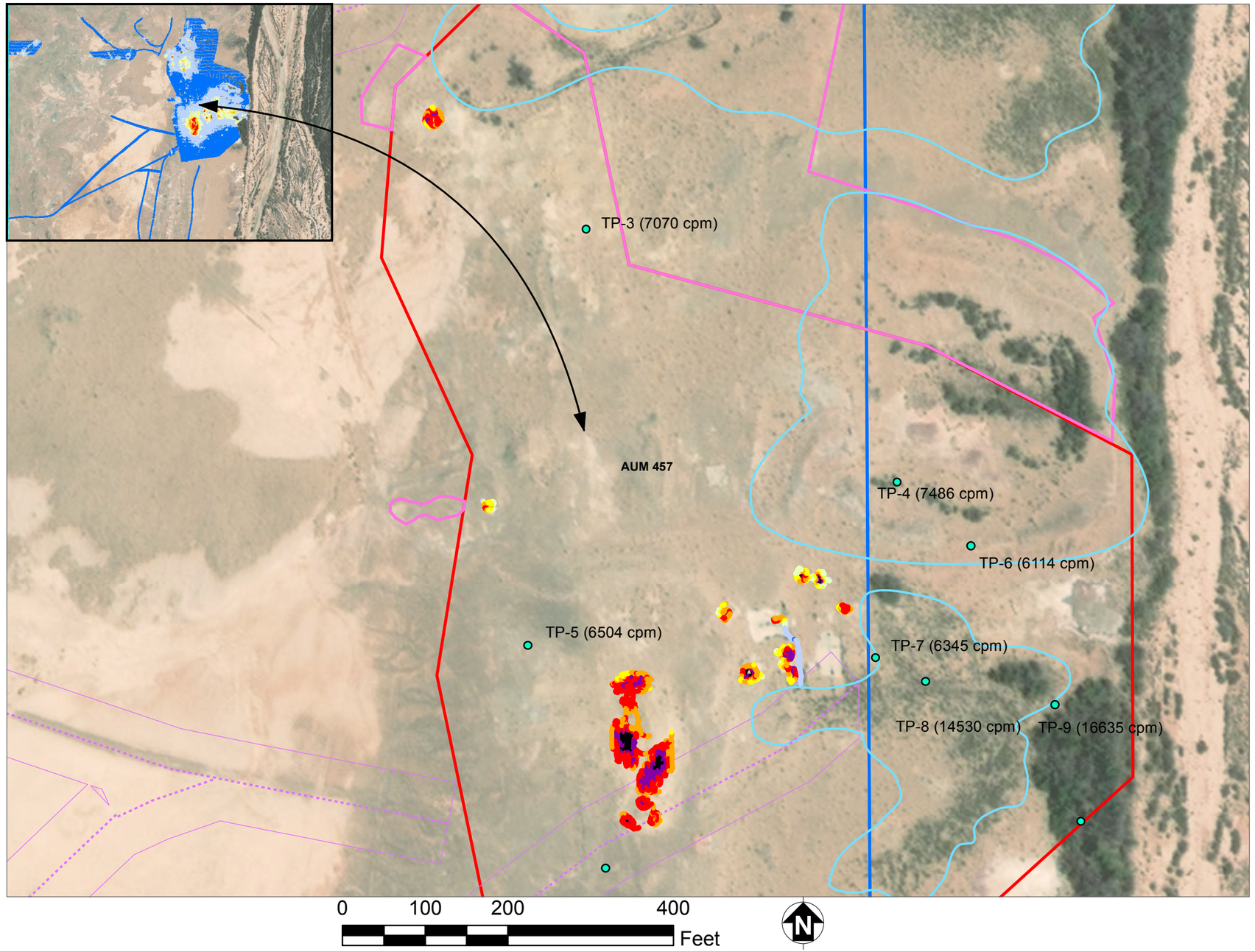
FIGURE 4-12
RESULTS OF MOBILE GAMMA SCAN SURVEY SW QUADRANT
BABBITT RANCHES



LEGEND

- Phase III Test Pit Actual Locations With Max Gamma Results
- EPA AUM Boundary
- Area of Potential Effect
- Section Lines
- Other Mine Related Disturbance (6)
- EPA Identified Drainage Area Boundary
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline

Total Gamma (cpm)

- 14034 - 53184
- 53185 - 125687
- 125688 - 242715
- 242716 - 442102
- 442103 - 717439
- 717440 - 999960
- 999961 - 1293180
- 1293181 - 1922580

NOTES:
1) IL Values are provided on Table 5-22.

Pooled BSA	95% Gamma UTL (cpm)	IL (cpm)
Alluvial BSA #1 and # 2, Terrace BSA #1 and #2, EPA "Qter BRA"	48,212	51,824
Drainage BSA # 2	43,564	47,176
Little Colorado River BSA	26,053	29,665

2) The IL Application Areas are shown on Figure 5-14.
3) Test Pit Gamma Readings are the maximum gross reading encountered in the test pit (December 2018).
4) Test Pit Gamma Scans were completed using a 2-inch x 2-inch NaI detector.
5) Gamma Scan Results were completed using a 3-inch x 3-inch NaI detector.
6) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 4-13 Additional scanning AUM 457 NE corner.mxd Date Saved: March 17, 2021

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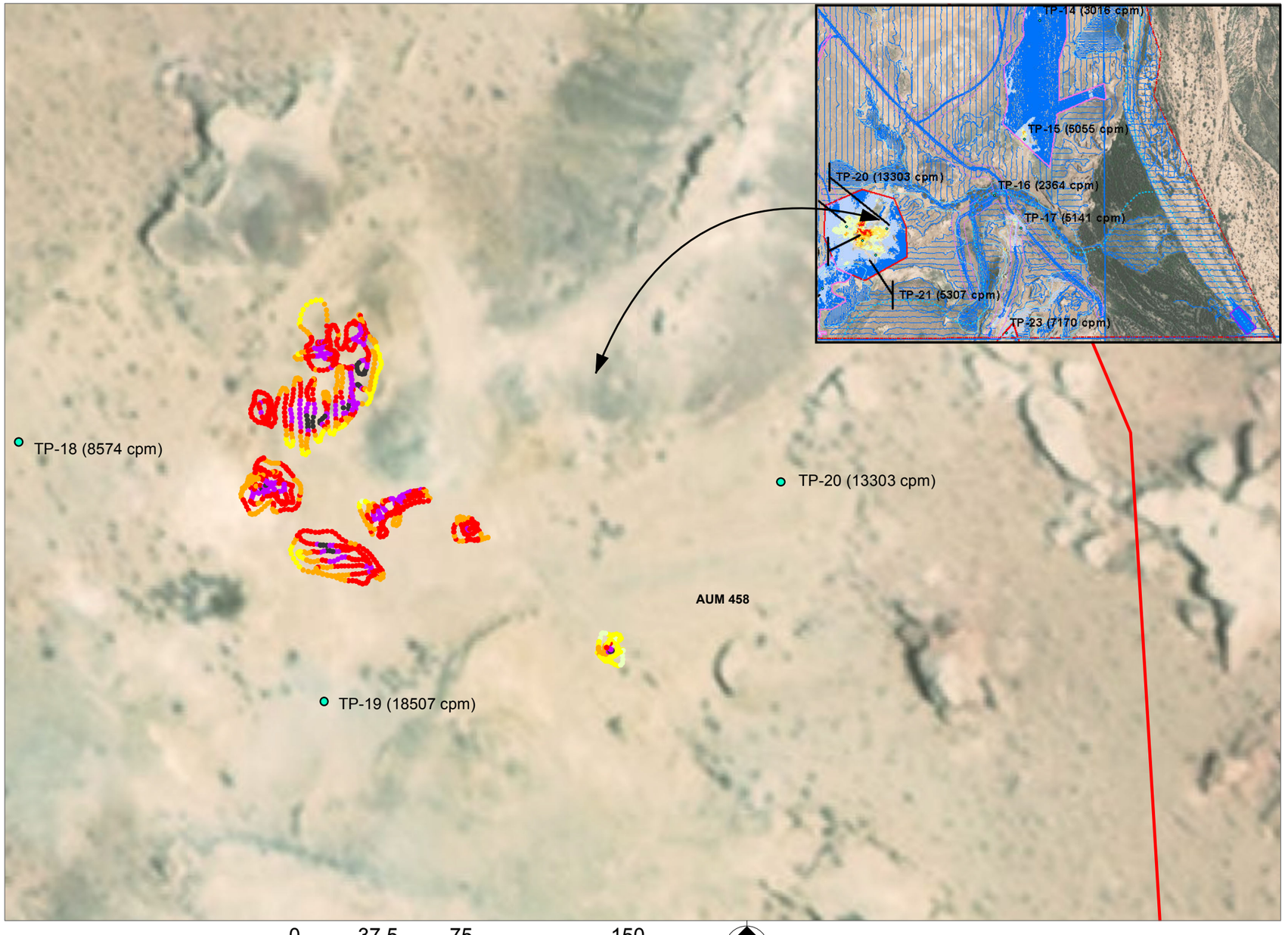
FIGURE 4-13
ADDITIONAL SCANNING, AUM 457 (CPM), NE QUADRANT
BABBITT RANCHES



LEGEND

- Phase III Test Pit Actual Locations With Max Gamma Results
- EPA AUM Boundary
- Area of Potential Effect
- Section Lines

Total Gamma (cpm)

- 14034 - 53184
- 53185 - 125687
- 125688 - 242715
- 242716 - 442102
- 442103 - 717439
- 717440 - 999960
- 999961 - 1293150
- 1293151 - 1922580

NOTES:
1) IL Values are provided on Table 5-22.

Pooled BSA	95% Gamma UTL (cpm)	IL (cpm)
Alluvial BSA #1 and # 2, Terrace BSA #1 and #2, EPA "Qter BRA"	48,212	51,824
Drainage BSA # 2	43,564	47,176
Little Colorado River BSA	26,053	29,665

2) The IL Application Areas are shown on Figure 5-14.
3) Test Pit Gamma Readings are the maximum gross reading encountered in the test pit (December 2018).
4) Test Pit Gamma Scans were completed using a 2-inch x 2-inch NaI detector.
5) Gamma Scan Results were completed using a 3-inch x 3-inch NaI detector.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 4-14 Additional scanning AUM 458 SE corner.mxd Date Saved: March, 17, 2021

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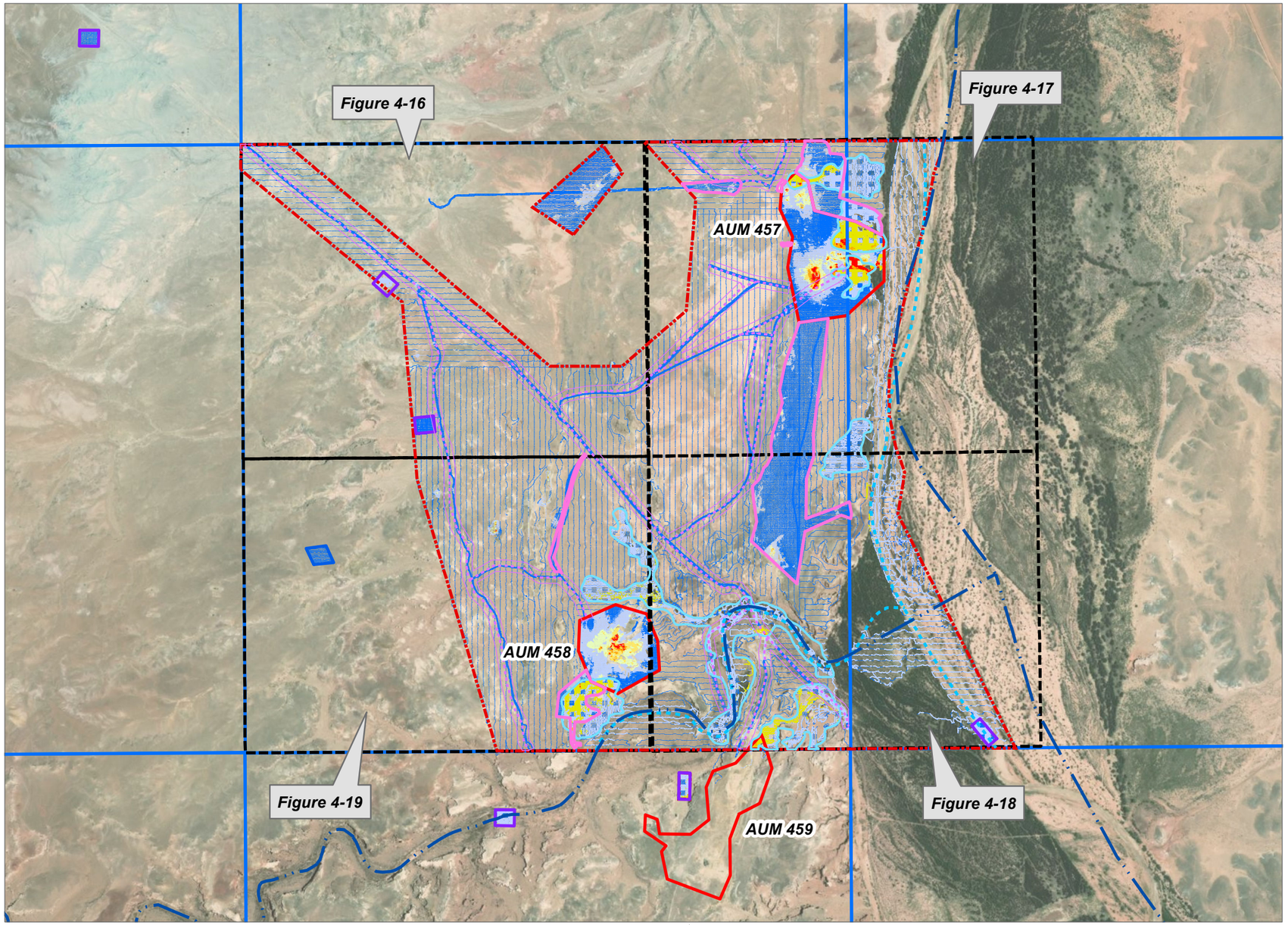
FIGURE 4-14
ADDITIONAL SCANNING AREA, AUM 458 (CPM), SE QUADRANT
BABBITT RANCHES



LEGEND

- 2019 Little Colorado River (NHD)
- **EPA AUM Boundary**
- **EPA BRA Location**
- **Babbitt BSA Locations**
- **Area of Potential Effect**
- **Section Lines**
- Other Mine Related Disturbance
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline

Total Gamma (cpm)

- 14034 - 53184
- 53185 - 125687
- 125688 - 242715
- 242716 - 442102
- 442103 - 717439
- 717440 - 999960

NOTES:
1) IL Values are provided on Table 5-22.

Pooled BSA	95% Gamma UTL (cpm)	IL (cpm)
Alluvial BSA #1 and # 2, Terrace BSA #1 and #2, EPA "Qter BRA"	48,212	51,824
Drainage BSA # 2	43,564	47,176
Little Colorado River BSA	26,053	29,665

2) The IL Application Areas are shown on Figure 5-14.
3) Test Pit Gamma Readings are the maximum gross reading encountered in the test pit (December 2018).
4) Test Pit Gamma Scans were completed using a 2-inch x 2-inch NaI detector.
5) Gamma Scan Results were completed using a 3-inch x 3-inch NaI detector.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 4-15 Gamma Scan Survey.mxd Date Saved: March, 17, 2021

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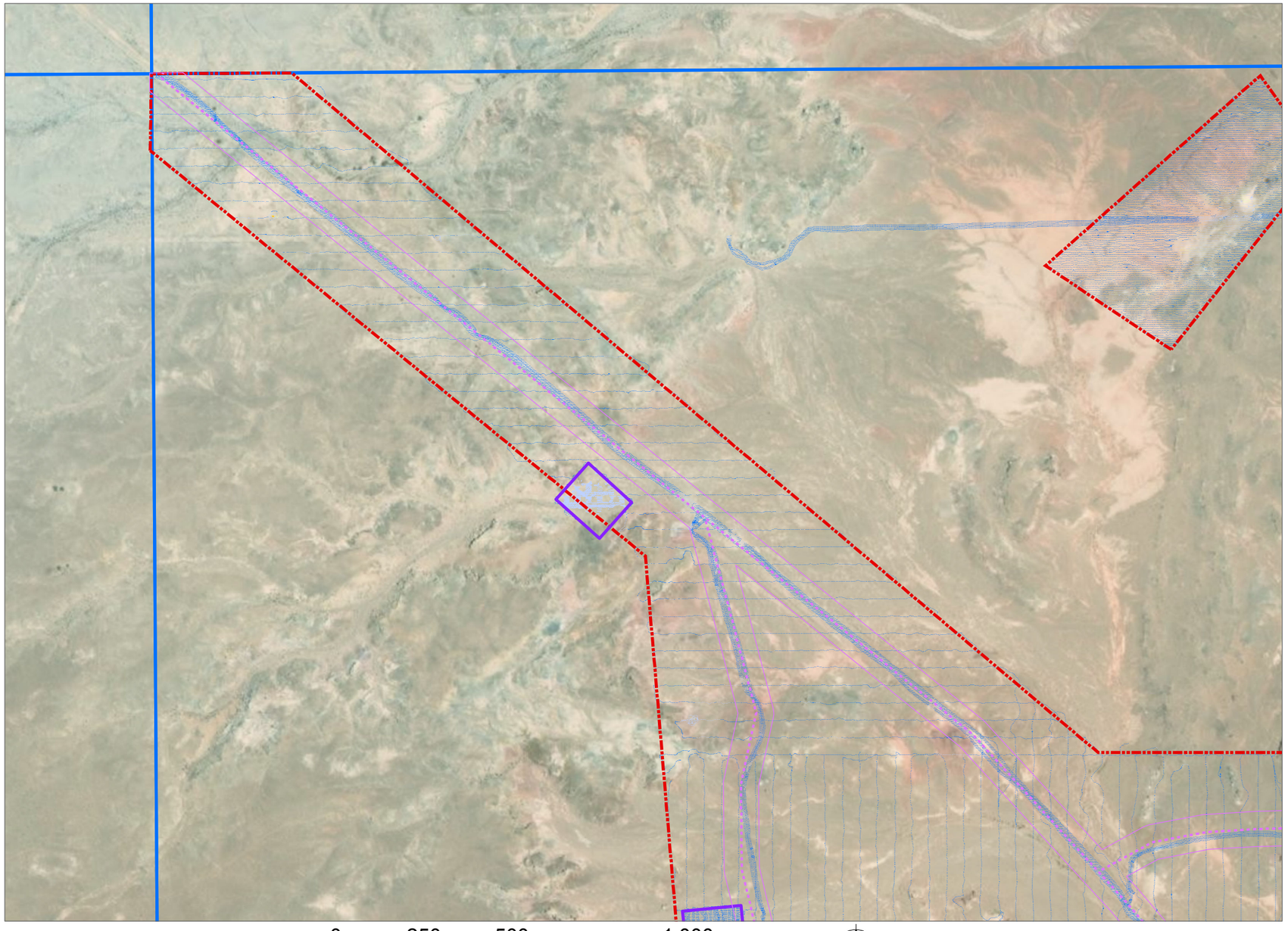
FIGURE 4-15
RESULTS OF MOBILE GAMMA SCAN SURVEY (CPM)
BABBITT RANCHES



LEGEND

- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline

Total Gamma (cpm)

- 14034 - 53184
- 53185 - 125687
- 125688 - 242715
- 242716 - 442102
- 442103 - 717439
- 717440 - 999960

NOTES:
1) IL Values are provided on Table 5-22.

Pooled BSA	95% Gamma UTL (cpm)	IL (cpm)
Alluvial BSA #1 and # 2, Terrace BSA #1 and #2, EPA "Qter BRA"	48,212	51,824
Drainage BSA # 2	43,564	47,176
Little Colorado River BSA	26,053	29,665

2) The IL Application Areas are shown on Figure 5-14.
3) Test Pit Gamma Readings are the maximum gross reading encountered in the test pit (December 2018).
4) Test Pit Gamma Scans were completed using a 2-inch x 2-inch NaI detector.
5) Gamma Scan Results were completed using a 3-inch x 3-inch NaI detector.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 4-16 Gamma Scan Survey NW CORNER.mxd Date Saved: March, 17, 2021

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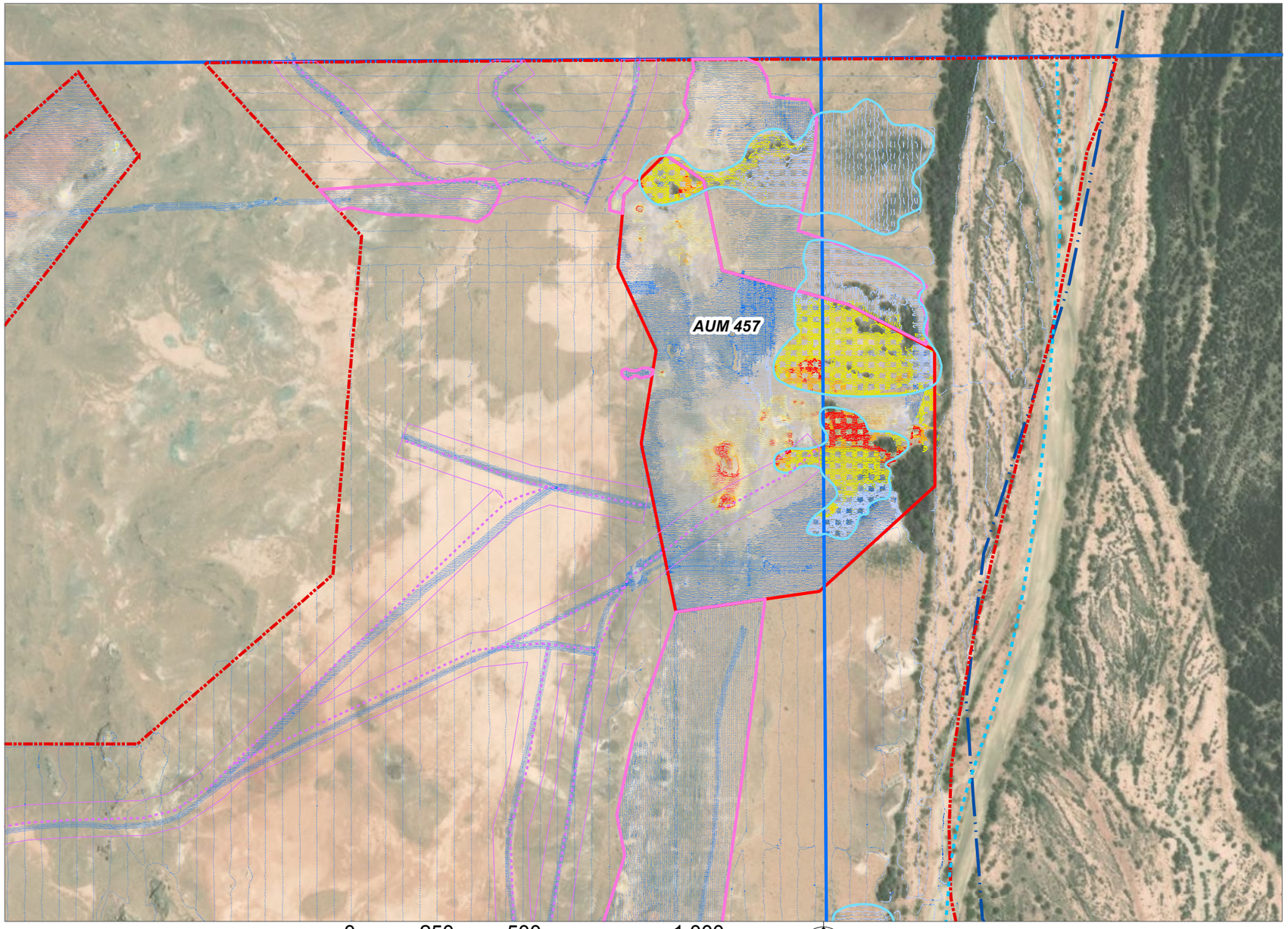
FIGURE 4-16
RESULTS OF MOBILE GAMMA SCAN SURVEY (CPM), NW QUADRANT
BABBITT RANCHES



LEGEND

- EPA Identified Road Centerline
- EPA Identified Drainage Network
- EPA Identified Drainage Area Boundary
- EPA Identified Road Buffer (50-ft)
- Other Mine Related Disturbance (6)
- **Area of Potential Effect**
- **Section Lines**
- **EPA AUM Boundary**
- 2019 Little Colorado River (NHD)

Total Gamma (cpm)

- 14034 - 53184
- 53185 - 125687
- 125688 - 242715
- 242716 - 442102
- 442103 - 717439
- 717440 - 999960

NOTES:

1) IL Values are provided on Table 5-22.

Pooled BSA	95% Gamma UTL (cpm)	IL (cpm)
Alluvial BSA #1 and # 2, Terrace BSA #1 and #2, EPA "Qter BRA"	48,212	51,824
Drainage BSA # 2	43,564	47,176
Little Colorado River BSA	26,053	29,665

2) The IL Application Areas are shown on Figure 5-14.
3) Test Pit Gamma Readings are the maximum gross reading encountered in the test pit (December 2018).
4) Test Pit Gamma Scans were completed using a 2-inch x 2-inch NaI detector.
5) Gamma Scan Results were completed using a 3-inch x 3-inch NaI detector.
6) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).

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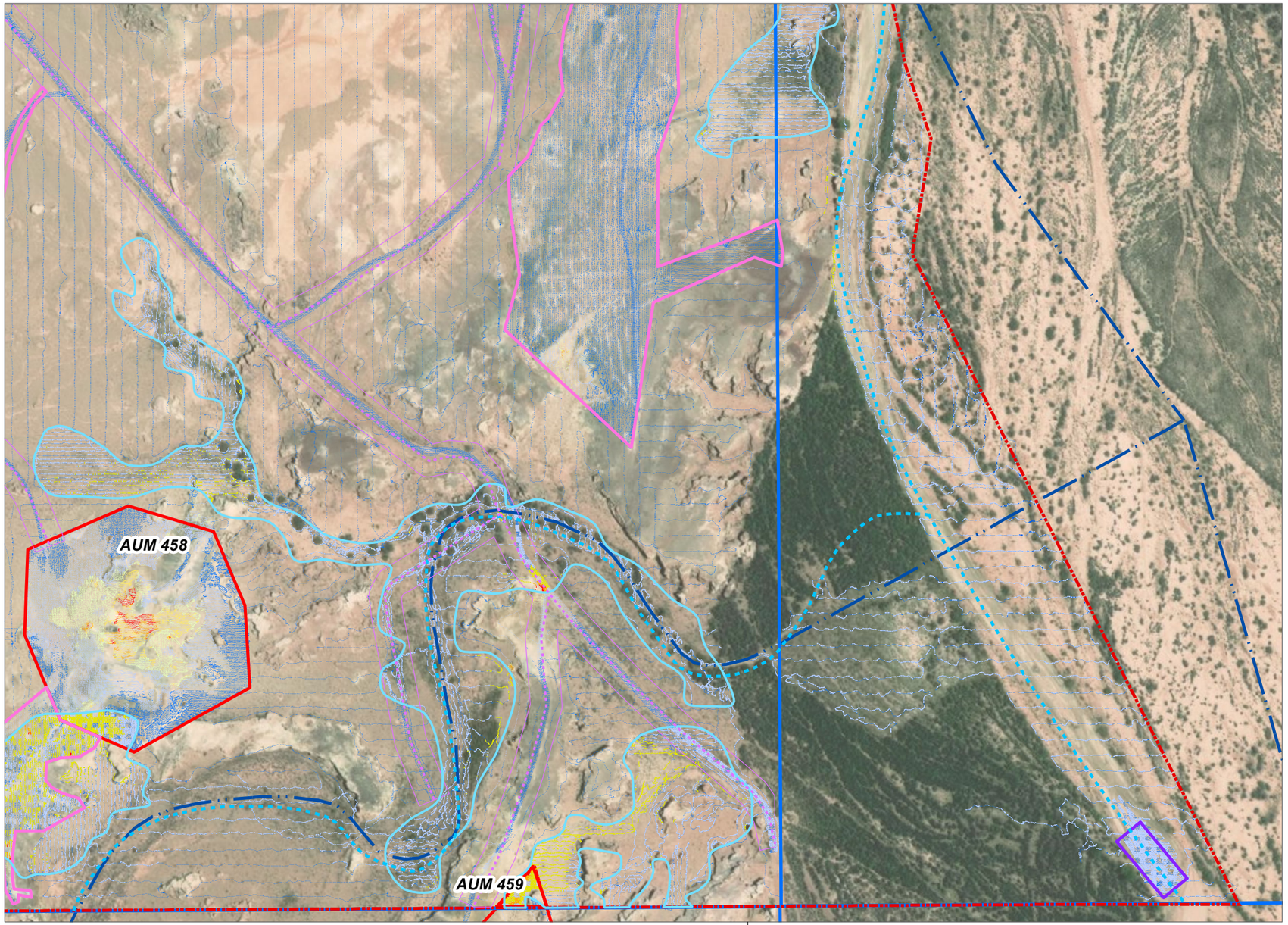
FIGURE 4-17
RESULTS OF MOBILE GAMMA SCAN SURVEY (CPM), NE QUADRANT
BABBITT RANCHES



LEGEND

- EPA Identified Road Centerline
- EPA Identified Drainage Network
- EPA Identified Drainage Area Boundary
- EPA Identified Road Buffer (50-ft)
- Other Mine Related Disturbance (6)
- **Babbitt BSA Locations**
- **Area of Potential Effect**
- **Section Lines**
- **EPA AUM Boundary**
- 2019 Little Colorado River (NHD)

Total Gamma (cpm)

- 14034 - 53184
- 53185 - 125687
- 125688 - 242715
- 242716 - 442102
- 442103 - 717439
- 717440 - 999960

NOTES:
1) IL Values are provided on Table 5-22.

Pooled BSA	95% Gamma UTL (cpm)	IL (cpm)
Alluvial BSA #1 and # 2, Terrace BSA #1 and #2, EPA "Qter BRA"	48,212	51,824
Drainage BSA # 2	43,564	47,176
Little Colorado River BSA	26,053	29,665

2) The IL Application Areas are shown on Figure 5-14.
3) Test Pit Gamma Readings are the maximum gross reading encountered in the test pit (December 2018).
4) Test Pit Gamma Scans were completed using a 2-inch x 2-inch NaI detector.
5) Gamma Scan Results were completed using a 3-inch x 3-inch NaI detector.
6) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).

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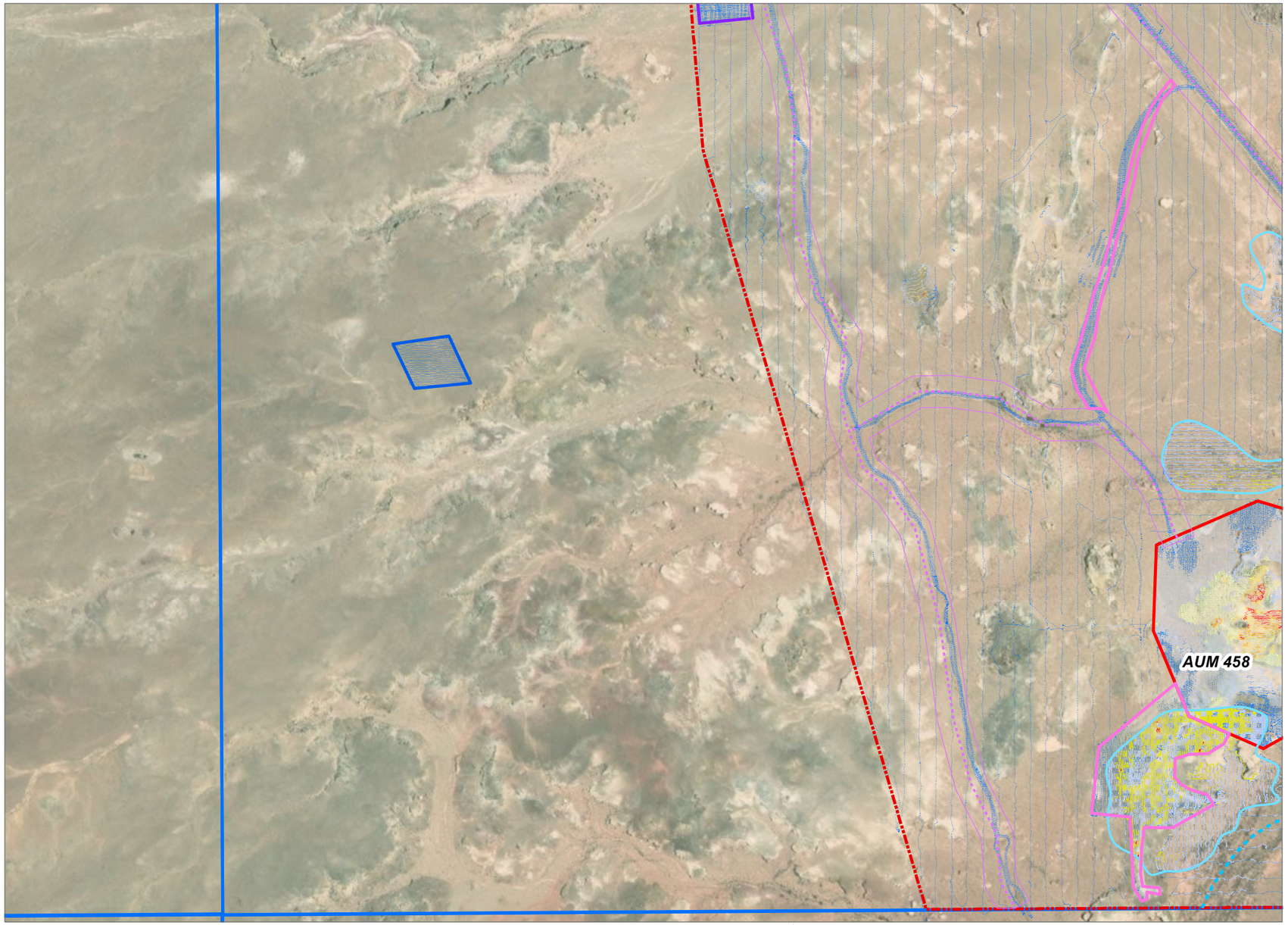
FIGURE 4-18
RESULTS OF MOBILE GAMMA SCAN SURVEY (CPM), SE QUADRANT
BABBITT RANCHES



LEGEND

- EPA AUM Boundary
- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- Other Mine Related Disturbance (6)
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline

Total Gamma (cpm)

- 14034 - 53184
- 53185 - 125687
- 125688 - 242715
- 242716 - 442102
- 442103 - 717439
- 717440 - 999960

NOTES:
1) IL Values are provided on Table 5-22.

Pooled BSA	95% Gamma UTL (cpm)	IL (cpm)
Alluvial BSA #1 and # 2, Terrace BSA #1 and #2, EPA "Qter BRA"	48,212	51,824
Drainage BSA # 2	43,564	47,176
Little Colorado River BSA	26,053	29,665

2) The IL Application Areas are shown on Figure 5-14.
3) Test Pit Gamma Readings are the maximum gross reading encountered in the test pit (December 2018).
4) Test Pit Gamma Scans were completed using a 2-inch x 2-inch NaI detector.
5) Gamma Scan Results were completed using a 3-inch x 3-inch NaI detector.
6) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 4-19 Gamma Scan Survey SW CORNER.mxd Date Saved: March, 17, 2021

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FIGURE 4-19
RESULTS OF MOBILE GAMMA SCAN SURVEY (CPM), SW QUADRANT
BABBITT RANCHES

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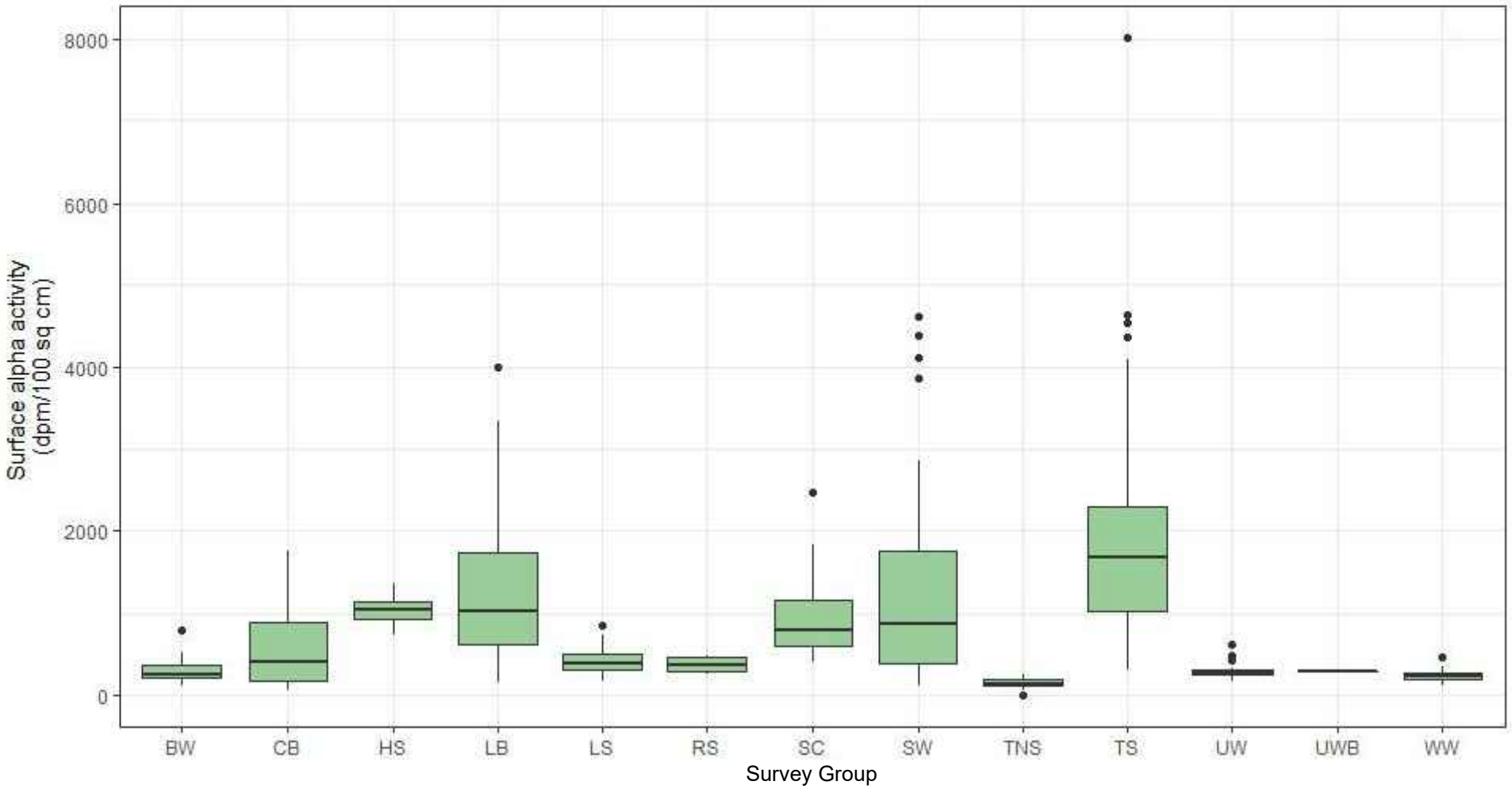

NOTES:

- IN A TUKEY-STYLE BOXPLOT, BOXES REPRESENT THE 25TH-75TH PERCENTILES OF DATA AND DARK LINES THE MEDIAN. POTENTIAL OUTLIERS ARE IDENTIFIED AS DOTS, WHILE WHISKERS SHOW THE RANGE OF THE REMAINDER OF THE DATA.
- ERG CLASSIFIED THE LOCATIONS TO BE SURVEYED INTO 13 GROUPS: BOTTOM WALL (BW), CEMENT BOX (CB), HIGHEST SLAB (HS), LOWER BLOCK (LB), LOWER SLAB (LS), REAR SLAB (RS), SMALL CORRIDOR (SC), SMALL WALL (SW), TOP NORTHERN SLAB (TNS), TOP SLAB (TS), UPPER WALL (UW), UPPER WEST BLOCK (UWB), AND WEST WALL (WW).

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FIGURE 4-20
BOXPLOT SHOWING ALPHA SURFACE ACTIVITY BY SURVEY GROUP
BABBITT RANCHES

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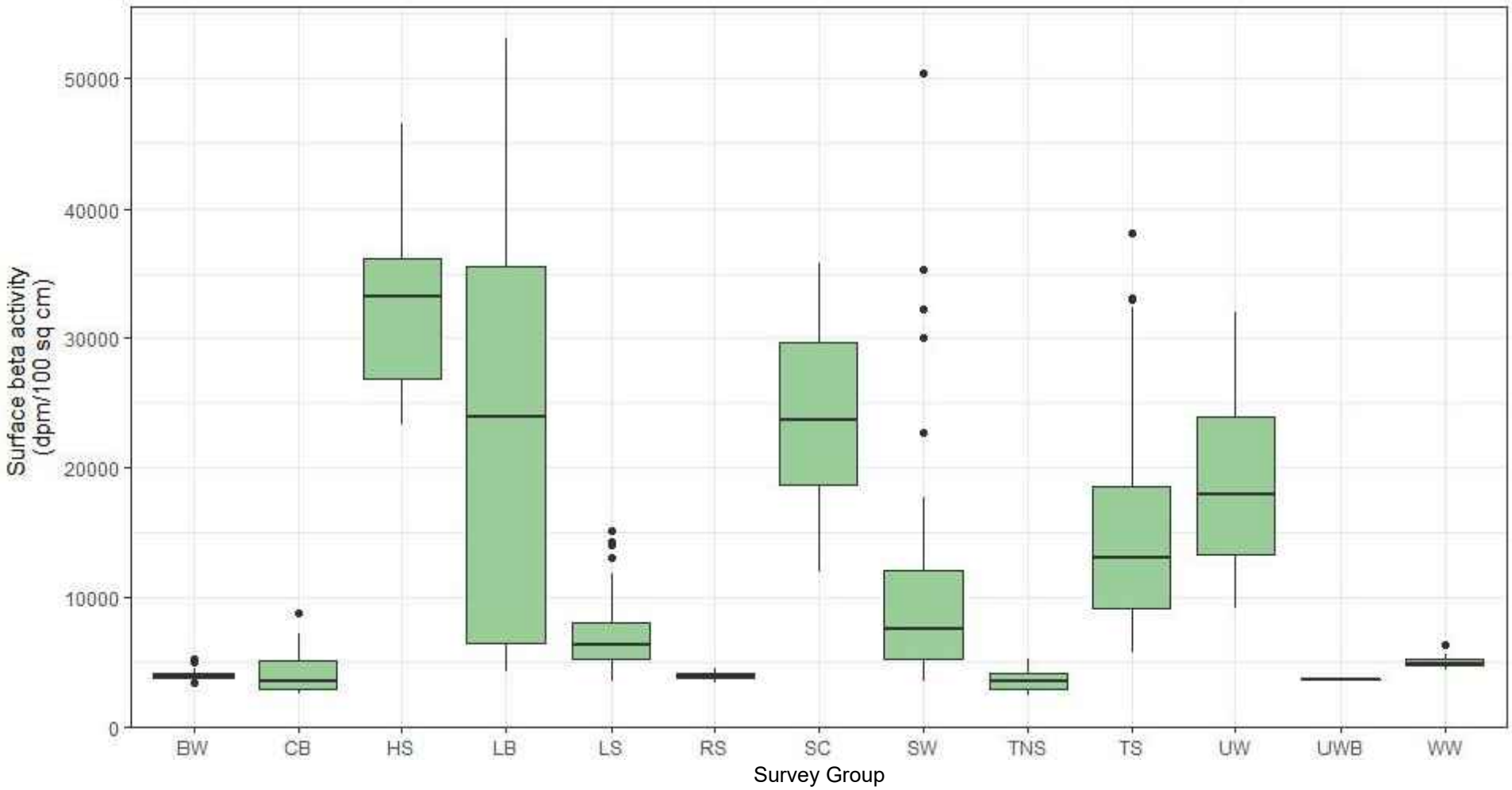

NOTES:

- IN A TUKEY-STYLE BOXPLOT, BOXES REPRESENT THE 25TH-75TH PERCENTILES OF DATA AND DARK LINES THE MEDIAN. POTENTIAL OUTLIERS ARE IDENTIFIED AS DOTS, WHILE WHISKERS SHOW THE RANGE OF THE REMAINDER OF THE DATA.
- ERG CLASSIFIED THE LOCATIONS TO BE SURVEYED INTO 13 GROUPS: BOTTOM WALL (BW), CEMENT BOX (CB), HIGHEST SLAB (HS), LOWER BLOCK (LB), LOWER SLAB (LS), REAR SLAB (RS), SMALL CORRIDOR (SC), SMALL WALL (SW), TOP NORTHERN SLAB (TNS), TOP SLAB (TS), UPPER WALL (UW), UPPER WEST BLOCK (UWB), AND WEST WALL (WW).

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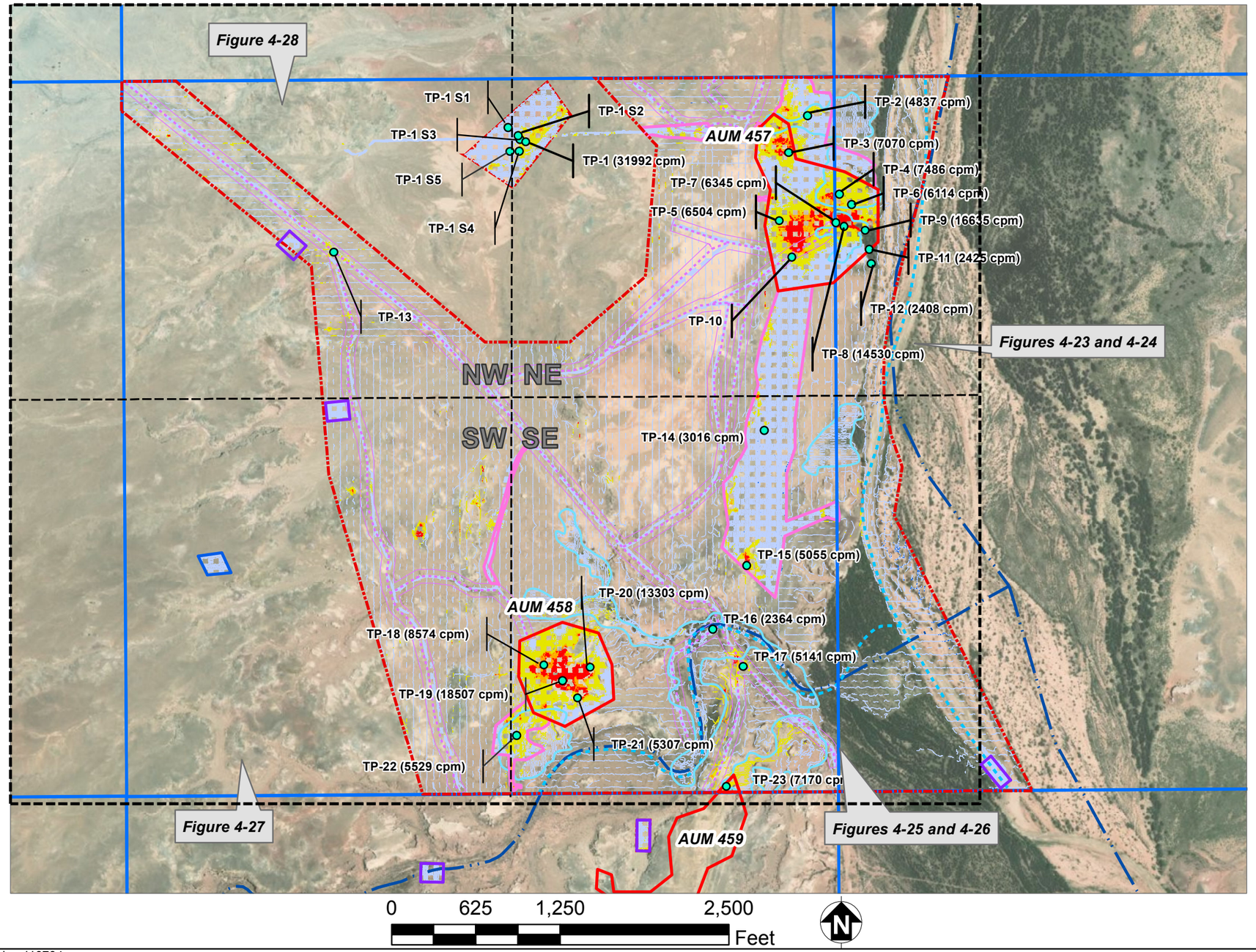
FIGURE 4-21
BOXPLOT SHOWING BETA SURFACE ACTIVITY BY SURVEY GROUP
BABBITT RANCHES



LEGEND

- Phase III Test Pit Actual Locations With Max Gamma Results
- EPA AUM Boundary
- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- Other Mine Related Disturbance (6)
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline
- 2019 Little Colorado River (NHD)

Gamma Scan Results Relative to Investigation Level (IL) (5)

- 0 - 0.5*IL
- >0.5*IL - 1*IL
- >1*IL - 2*IL
- >2*IL - 3*IL
- >3*IL

NOTES:
1) IL Values are provided on Table 5-22.

Pooled BSA	95% Gamma UTL (cpm)	IL (cpm)
Alluvial BSA #1 and # 2, Terrace BSA #1 and #2, EPA "Qter BRA"	48,212	51,824
Drainage BSA # 2	43,564	47,176
Little Colorado River BSA	26,053	29,665

2) The IL Application Areas are shown on Figure 5-14.
3) Test Pit Gamma Readings are the maximum gross reading encountered in the test pit (December 2018).
4) Test Pit Gamma Scans were completed using a 2-inch x 2-inch NaI detector.
5) Gamma Scan Results were completed using a 3-inch x 3-inch NaI detector.
6) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).

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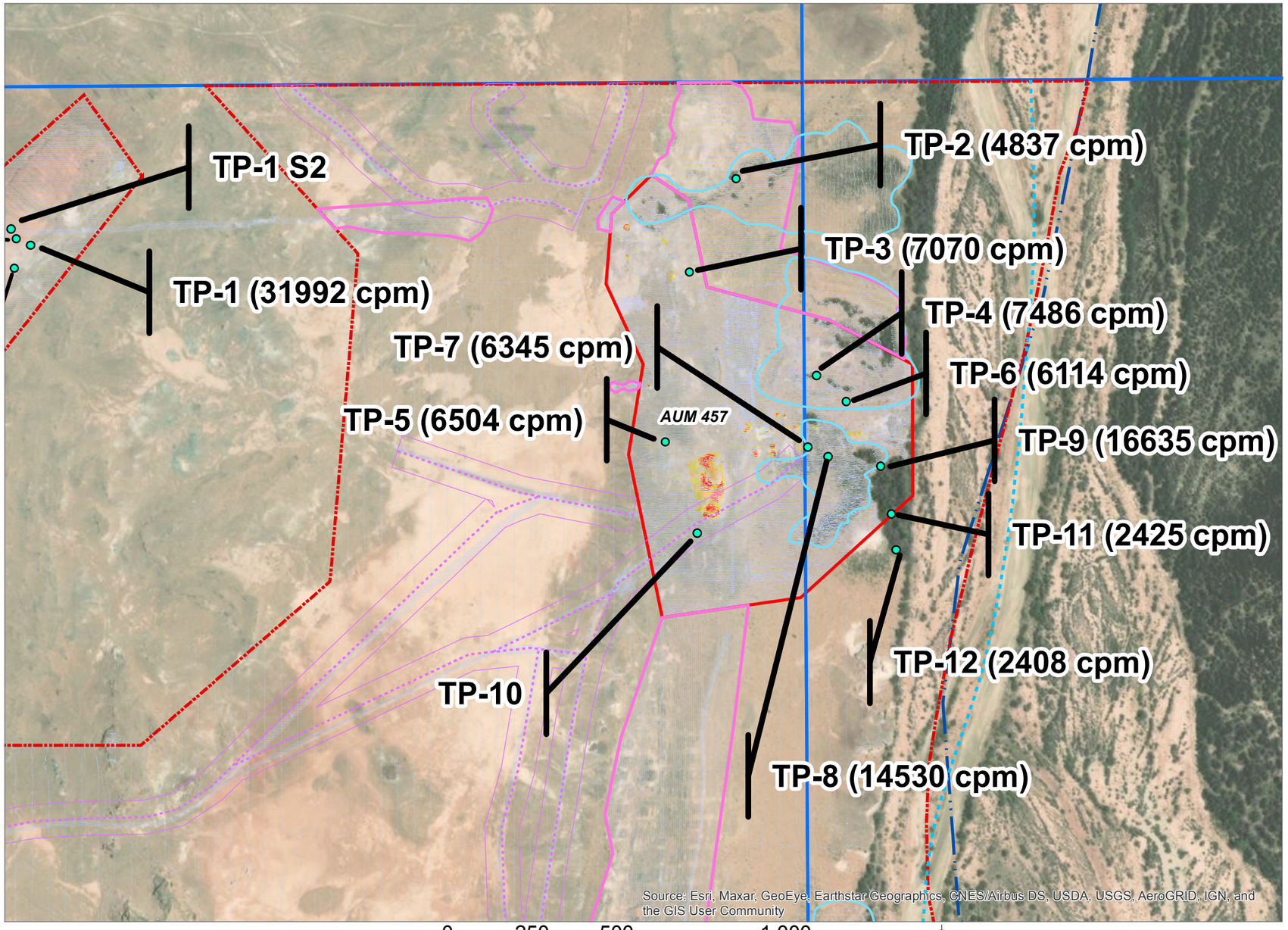
FIGURE 4-22
TEST PIT LOCATIONS AND MAXIMUM GAMMA READINGS
BABBITT RANCHES



LEGEND

- Phase III Test Pit Actual Locations With Max Gamma Results
- EPA Identified Road Centerline
- EPA Identified Drainage Network
- EPA Identified Drainage Area Boundary
- EPA Identified Road Buffer (50-ft)
- Other Mine Related Disturbance (6)
- **Area of Potential Effect**
- **Section Lines**
- **EPA AUM Boundary**
- 2019 Little Colorado River (NHD)

Gamma Scan Results Relative to Investigation Level (IL) (5)

- 0 - 0.5*IL
- >0.5*IL - 1*IL
- >1*IL - 2*IL
- >2*IL - 3*IL
- >3*IL

NOTES:
1) IL Values are provided on Table 5-22.

Pooled BSA	95% Gamma UTL (cpm)	IL (cpm)
Alluvial BSA #1 and # 2, Terrace BSA #1 and #2, EPA "Qter BRA"	48,212	51,824
Drainage BSA # 2	43,564	47,176
Little Colorado River BSA	26,053	29,665

2) The IL Application Areas are shown on Figure 5-14.
3) Test Pit Gamma Readings are the maximum gross reading encountered in the test pit (December 2018).
4) Test Pit Gamma Scans were completed using a 2-inch x 2-inch NaI detector.
5) Gamma Scan Results were completed using a 3-inch x 3-inch NaI detector.
6) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).

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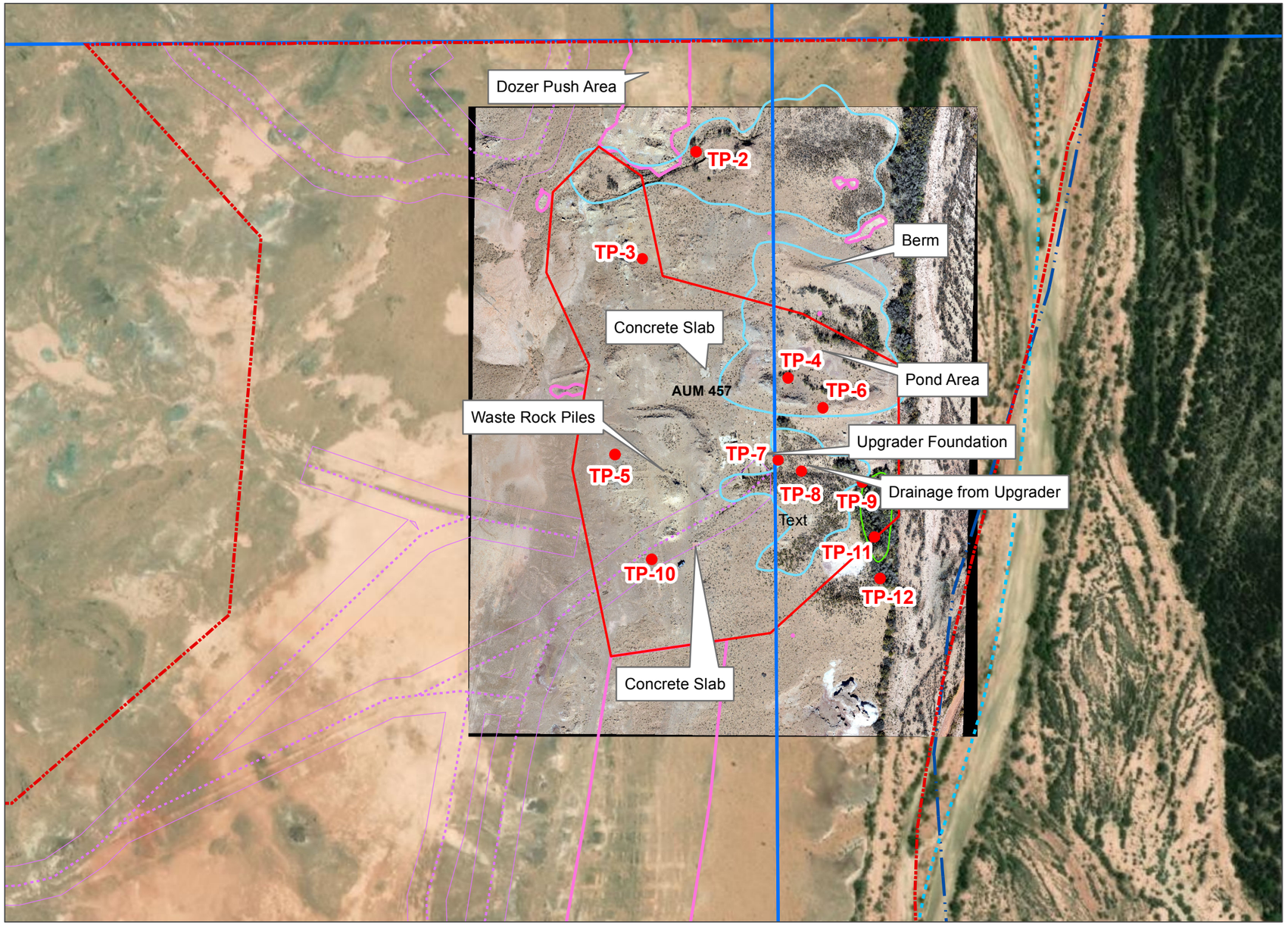
FIGURE 4-23
TEST PIT LOCATIONS WITH RESULTS OF GAMMA SCAN SURVEY (COMPARED TO IL), NE QUADRANT
BABBITT RANCHES



LEGEND

- Phase III Test Pits
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- EPA Identified "Wetland 3"
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline
- Other Mine Related Disturbance (1)
- 2019 Little Colorado River (NHD)

NOTES:
1) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).
2) High Resolution photo from Maser (2016)
3) For informational purposes only - not for field implementation.

N

0 125 250 500
Feet

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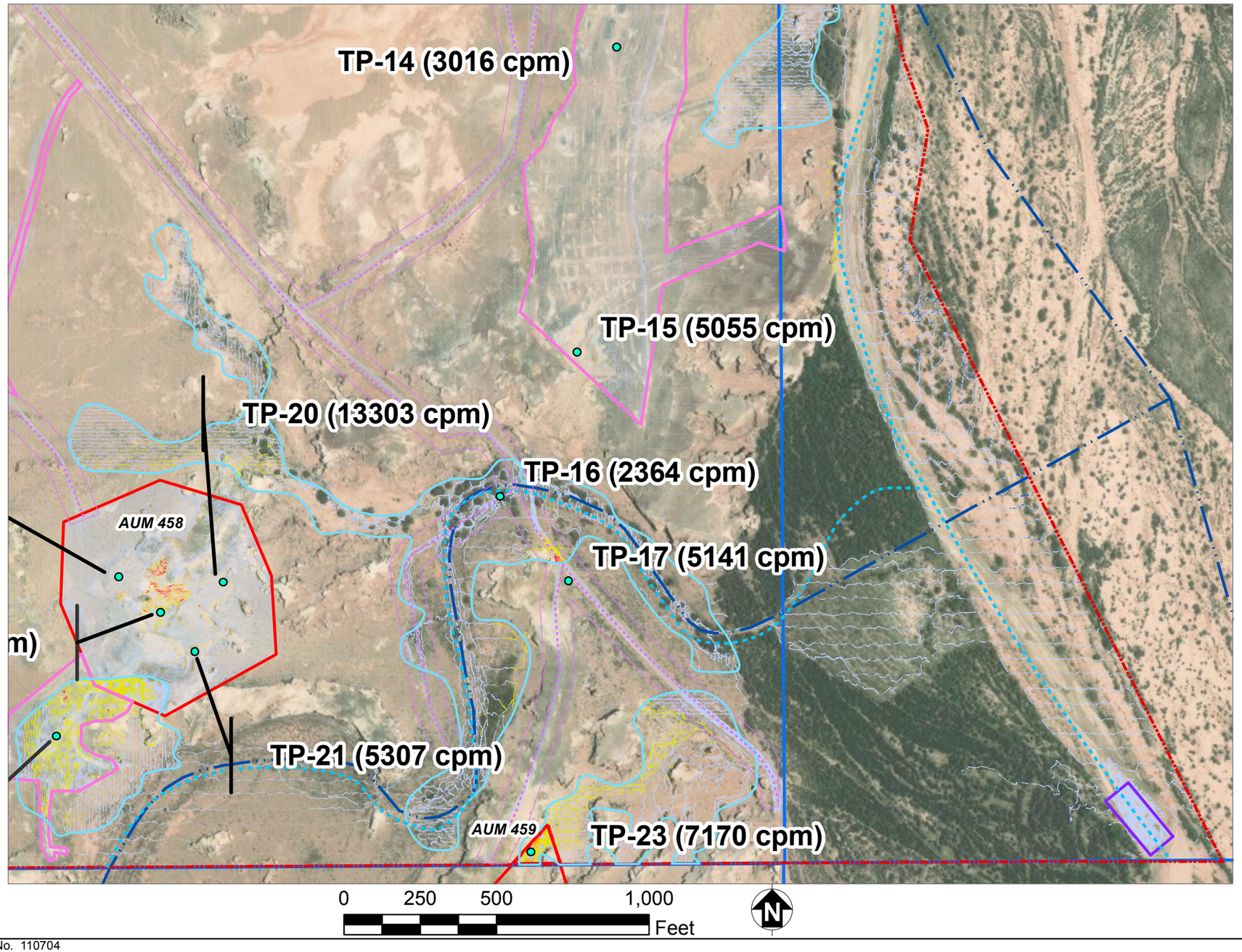
FIGURE 4-24
TEST PIT LOCATIONS IN AREA OF AUM 457
BABBITT RANCHES



LEGEND

- Phase III Test Pit Actual Locations With Max Gamma Results
- EPA Identified Road Centerline
- EPA Identified Drainage Network
- EPA Identified Drainage Area Boundary
- EPA Identified Road Buffer (50-ft)
- Other Mine Related Disturbance (6)
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary
- 2019 Little Colorado River (NHD)

Gamma Scan Results Relative to Investigation Level (IL) (5)

- 0 - 0.5*IL
- >0.5*IL - 1*IL
- >1*IL - 2*IL
- >2*IL - 3*IL
- >3*IL

NOTES:
1) IL Values are provided on Table 5-22.

Pooled BSA	95% Gamma UTL (cpm)	IL (cpm)
Alluvial BSA #1 and # 2, Terrace BSA #1 and #2, EPA "Qter BRA"	48,212	51,824
Drainage BSA # 2	43,564	47,176
Little Colorado River BSA	26,053	29,665

2) The IL Application Areas are shown on Figure 5-14.
3) Test Pit Gamma Readings are the maximum gross reading encountered in the test pit (December 2018).
4) Test Pit Gamma Scans were completed using a 2-inch x 2-inch NaI detector.
5) Gamma Scan Results were completed using a 3-inch x 3-inch NaI detector.
6) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).

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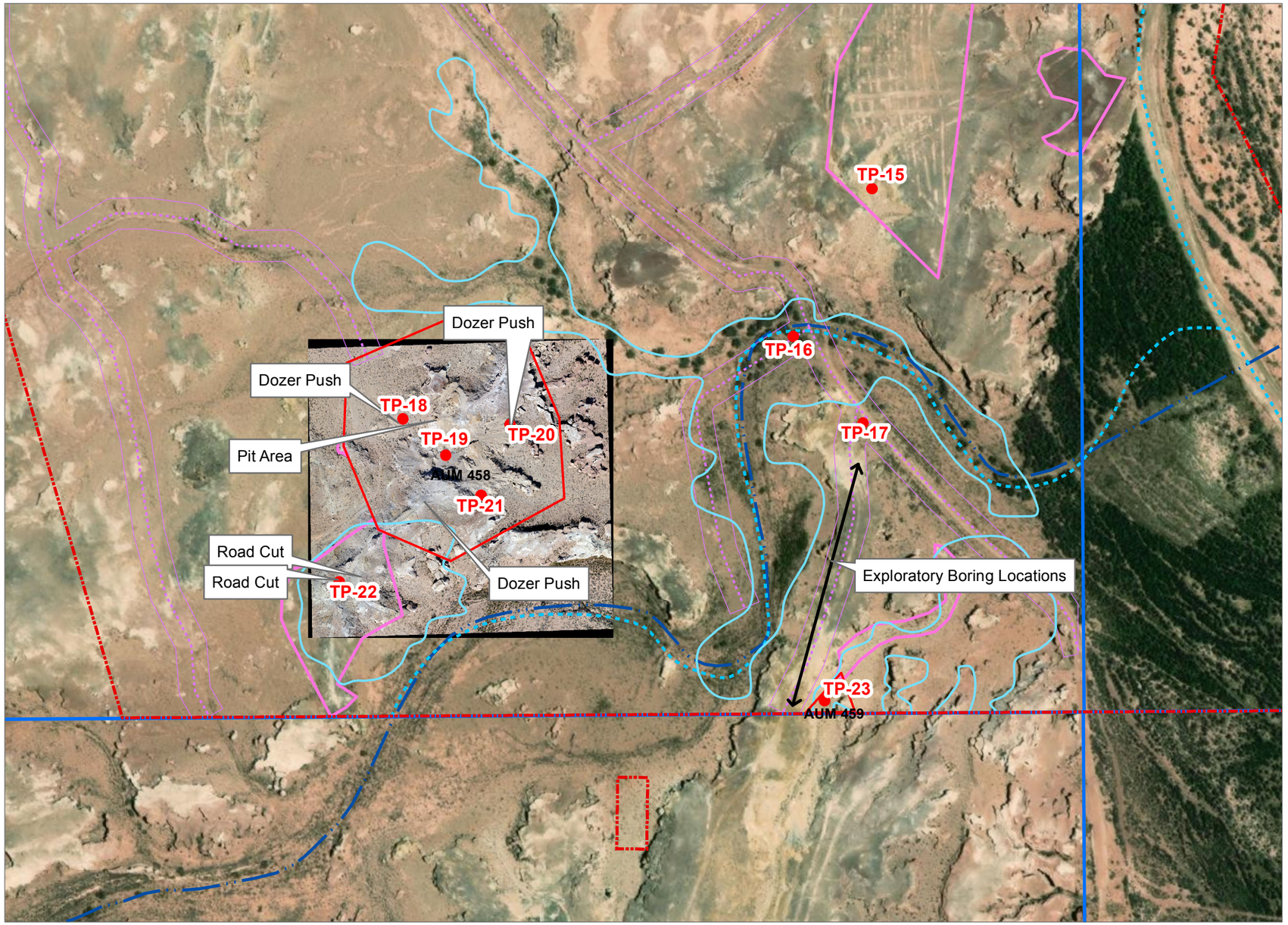
FIGURE 4-25
TEST PIT LOCATIONS WITH RESULTS OF GAMMA SCAN SURVEY (COMPARED TO IL), SE QUADRANT
BABBITT RANCHES



LEGEND

- Phase III Test Pits
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline
- Other Mine Related Disturbance (1)
- 2019 Little Colorado River (NHD)

Notes:

1) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).
2) High Resolution photo from Maser (2016)
3) For informational purposes only - not for field implementation.

N

0 250 500 1,000 Feet

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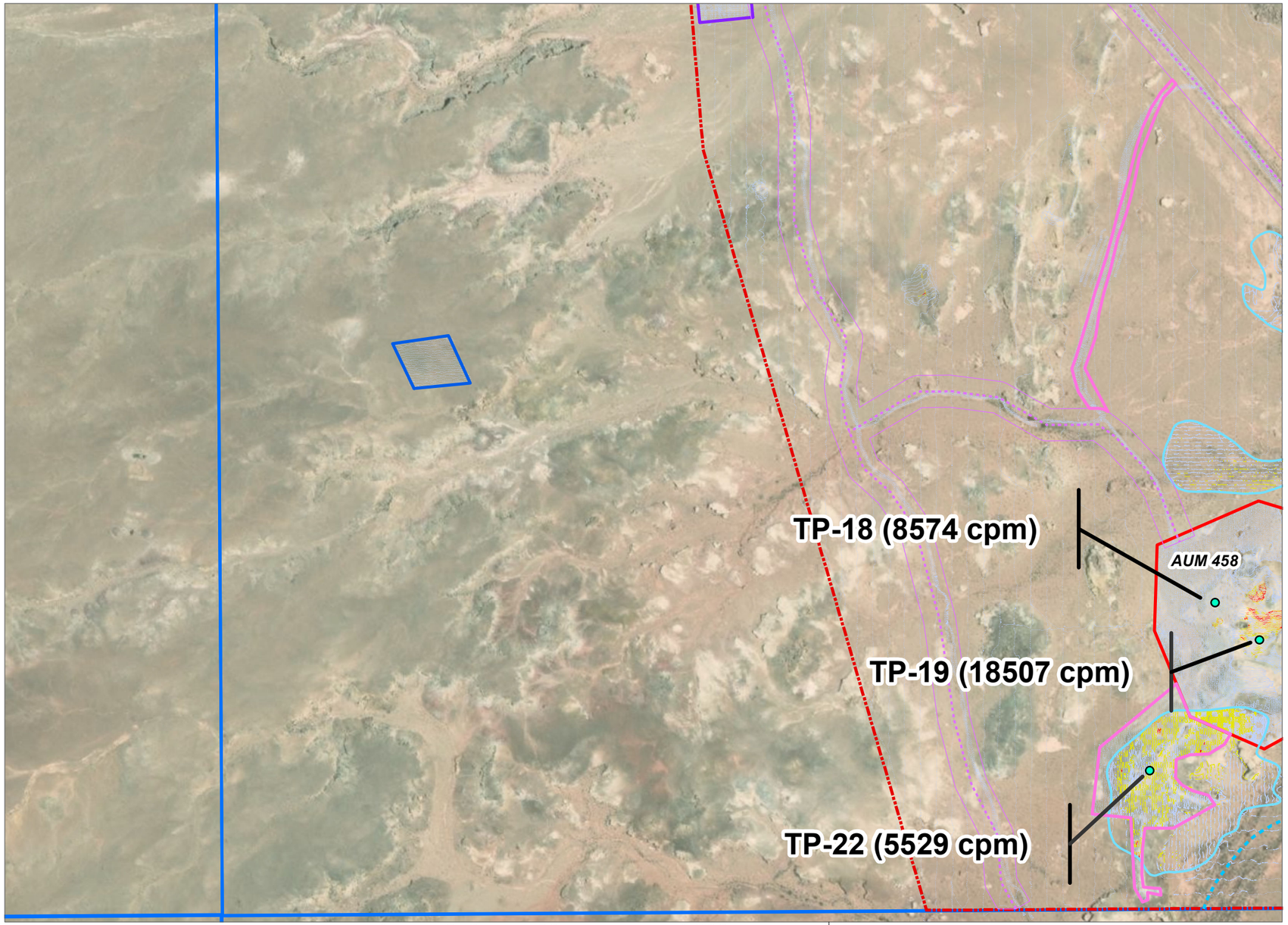
FIGURE 4-26
TEST PIT LOCATIONS IN AREA OF AUMS 458 AND 459
BABBITT RANCHES



LEGEND

- Phase III Test Pit Actual Locations With Max Gamma Results
- EPA AUM Boundary
- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- Other Mine Related Disturbance (6)
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline

Gamma Scan Results Relative to Investigation Level (IL) (5)

- 0 - 0.5*IL
- >0.5*IL - 1*IL
- >1*IL - 2*IL
- >2*IL - 3*IL
- >3*IL

NOTES:
1) IL Values are provided on Table 5-22.

Pooled BSA	95% Gamma UTL (cpm)	IL (cpm)
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Drainage BSA # 2	43,564	47,176
Little Colorado River BSA	26,053	29,665

2) The IL Application Areas are shown on Figure 5-14.
3) Test Pit Gamma Readings are the maximum gross reading encountered in the test pit (December 2018).
4) Test Pit Gamma Scans were completed using a 2-inch x 2-inch NaI detector.
5) Gamma Scan Results were completed using a 3-inch x 3-inch NaI detector.
6) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mxd\Fig 4-27 Test Pit Locations SW CORNER.mxd Date Saved: March, 17, 2021

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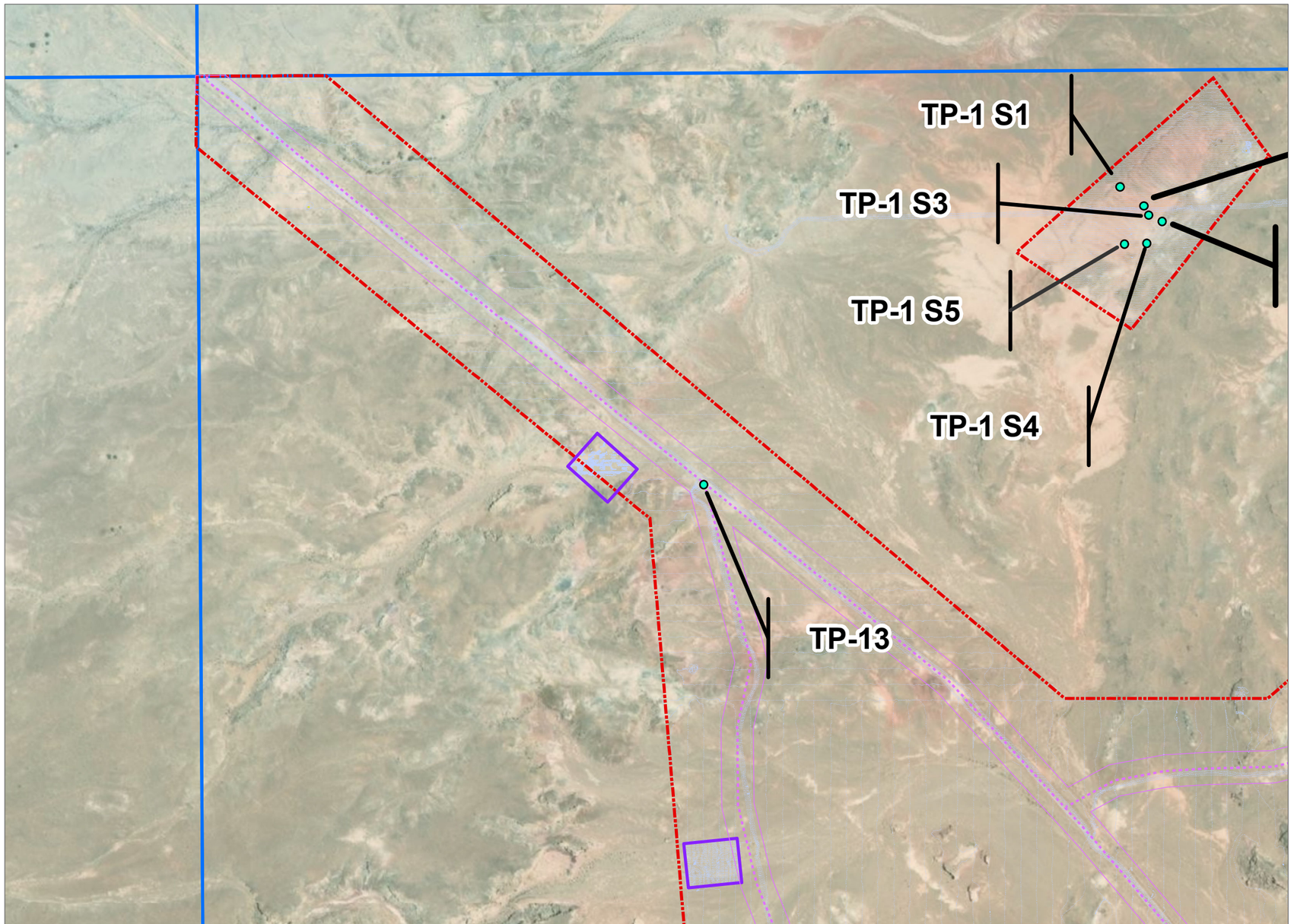
FIGURE 4-27
TEST PIT LOCATIONS WITH RESULTS OF GAMMA SCAN SURVEY (COMPARED TO IL), SW QUADRANT
BABBITT RANCHES



LEGEND

- Phase III Test Pit Actual Locations With Max Gamma Results
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline

Gamma Scan Results Relative to Investigation Level (IL) (5)

- 0 - 0.5*IL
- >0.5*IL - 1*IL
- >1*IL - 2*IL
- >2*IL - 3*IL
- >3*IL

NOTES:
1) IL Values are provided on Table 5-22.

Pooled BSA	95% Gamma UTL (cpm)	IL (cpm)
Alluvial BSA #1 and # 2, Terrace BSA #1 and #2, EPA "Qter BRA"	48,212	51,824
Drainage BSA # 2	43,564	47,176
Little Colorado River BSA	26,053	29,665

2) The IL Application Areas are shown on Figure 5-14.
3) Test Pit Gamma Readings are the maximum gross reading encountered in the test pit (December 2018).
4) Test Pit Gamma Scans were completed using a 2-inch x 2-inch NaI detector.
5) Gamma Scan Results were completed using a 3-inch x 3-inch NaI detector.
6) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 4-28 Test Pit Locations NW CORNER.mxd Date Saved: March, 17, 2021

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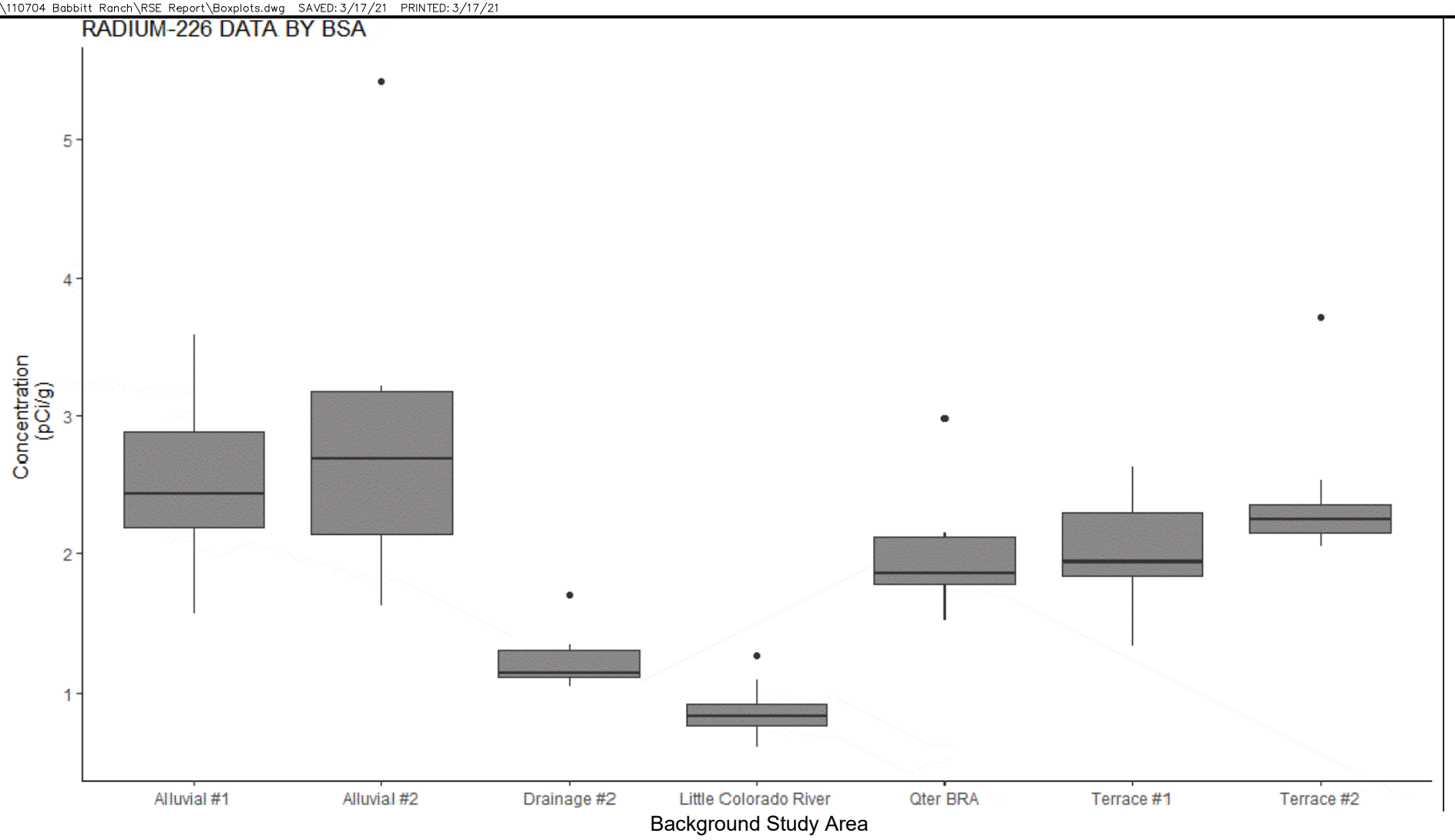
FIGURE 4-28
TEST PIT LOCATIONS WITH RESULTS OF GAMMA SCAN SURVEY (COMPARED TO IL), NW QUADRANT
BABBITT RANCHES

T:\110704 Babbitt Ranch\RSE Report\Boxplots.dwg SAVED: 3/17/21 PRINTED: 3/17/21



NOTE:
IN A TUKEY-STYLE BOXPLOT, BOXES REPRESENT THE 25th-75th PERCENTILES OF DATA AND DARK LINES THE MEDIAN.
POTENTIAL OUTLIERS ARE IDENTIFIED AS DOTS, WHILE WHISKERS SHOW THE RANGE OF THE REMAINDER OF THE DATA.

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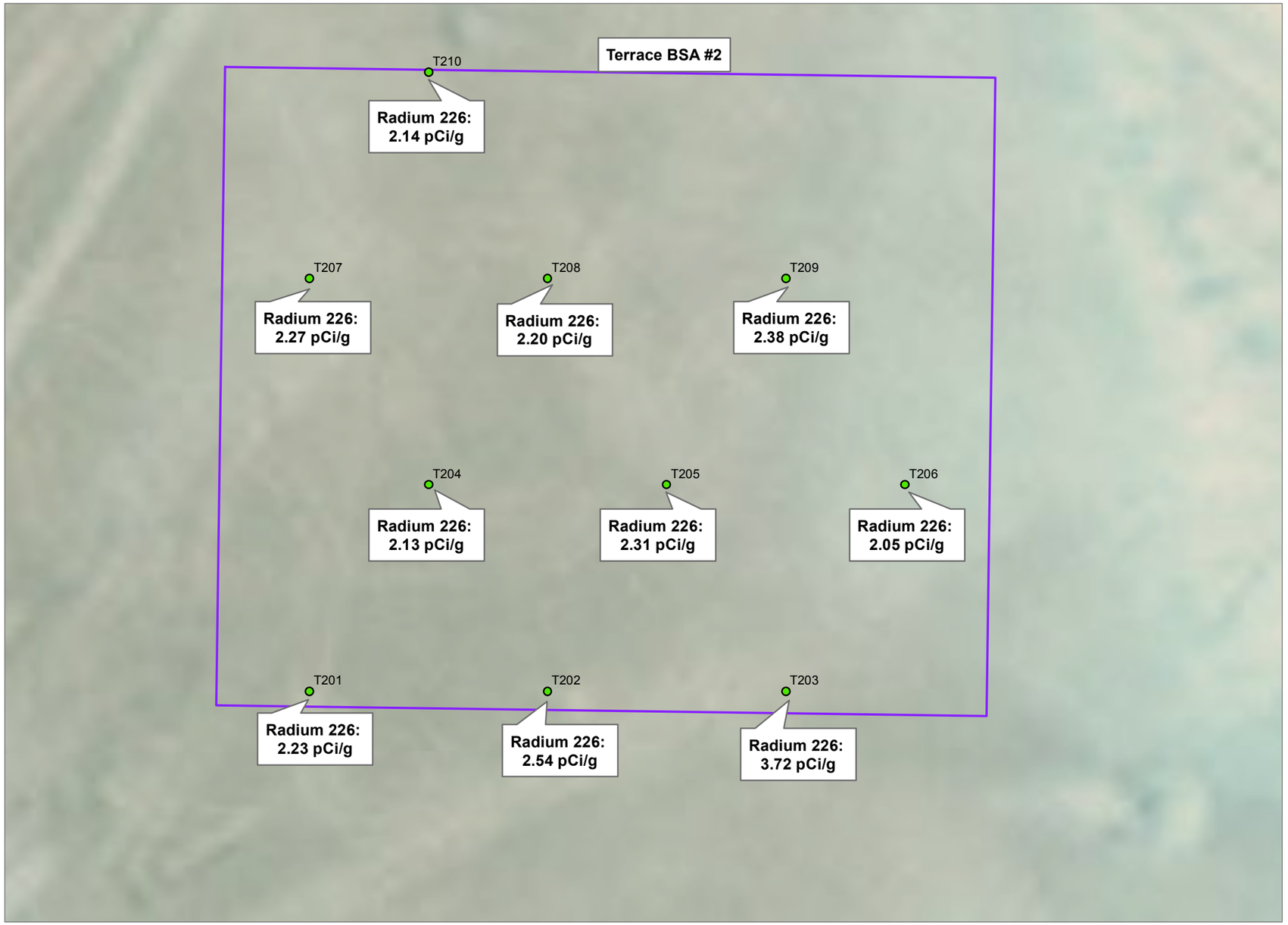
FIGURE 4-29
BOXPLOT SHOWING SOIL ACTIVITY CONCENTRATIONS OF RADIUM-226 BY BACKGROUND STUDY AREA
BABBITT RANCHES



LEGEND

- Soil Sample Location
- Babbitt BSA Locations

N

0 12.5 25 50

Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 4-30 Radium Terrace 2.mxd Date Saved: March, 17, 2021

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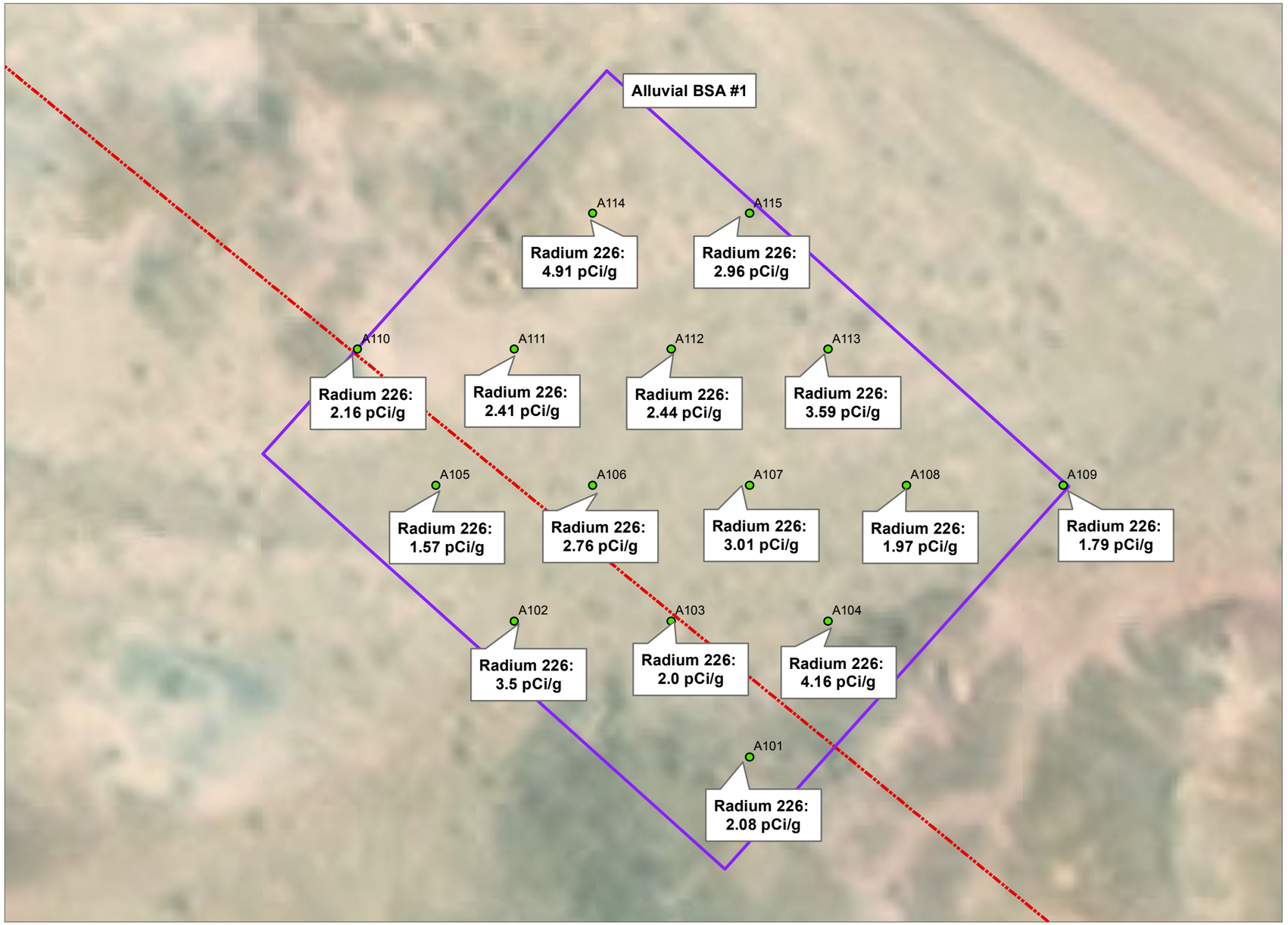
FIGURE 4-30
TERRACE BSA #2 RADIUM-226 CONCENTRATIONS
BABBITT RANCHES



LEGEND

- Soil Sample Location
- Babbitt BSA Locations
- Area of Potential Effect

N

0 15 30 60

Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 4-31 Radium Alluvial 1.mxd Date Saved: March, 17, 2021

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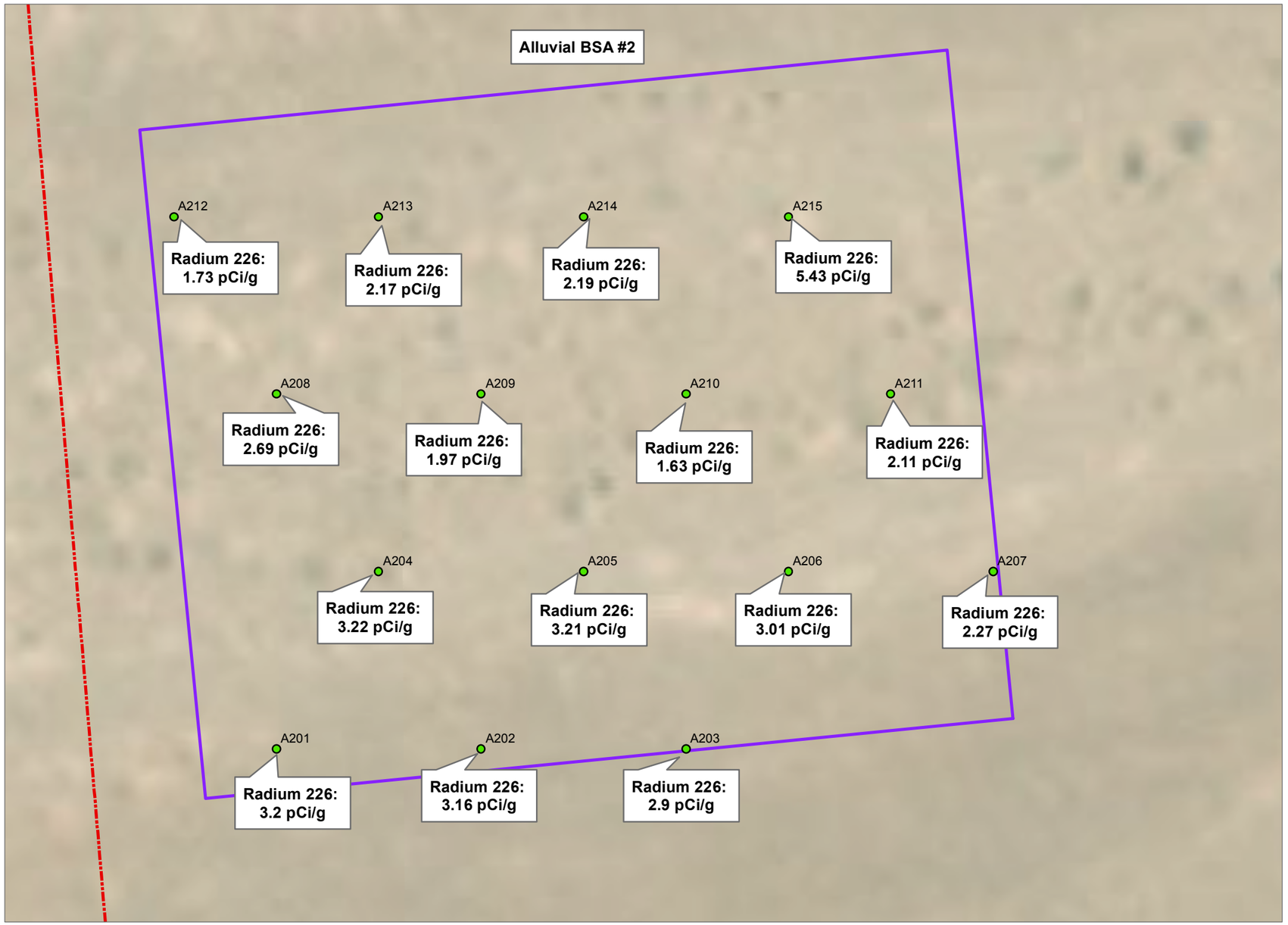
FIGURE 4-31
ALLUVIAL BSA #1 RADIUM-226 CONCENTRATIONS
BABBITT RANCHES



LEGEND

- Soil Sample Location
- Babbitt BSA Locations
- Area of Potential Effect

N

0 12.5 25 50

Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mxd\Fig 4-32 Radium Alluvial 2.mxd Date Saved: March, 17, 2021

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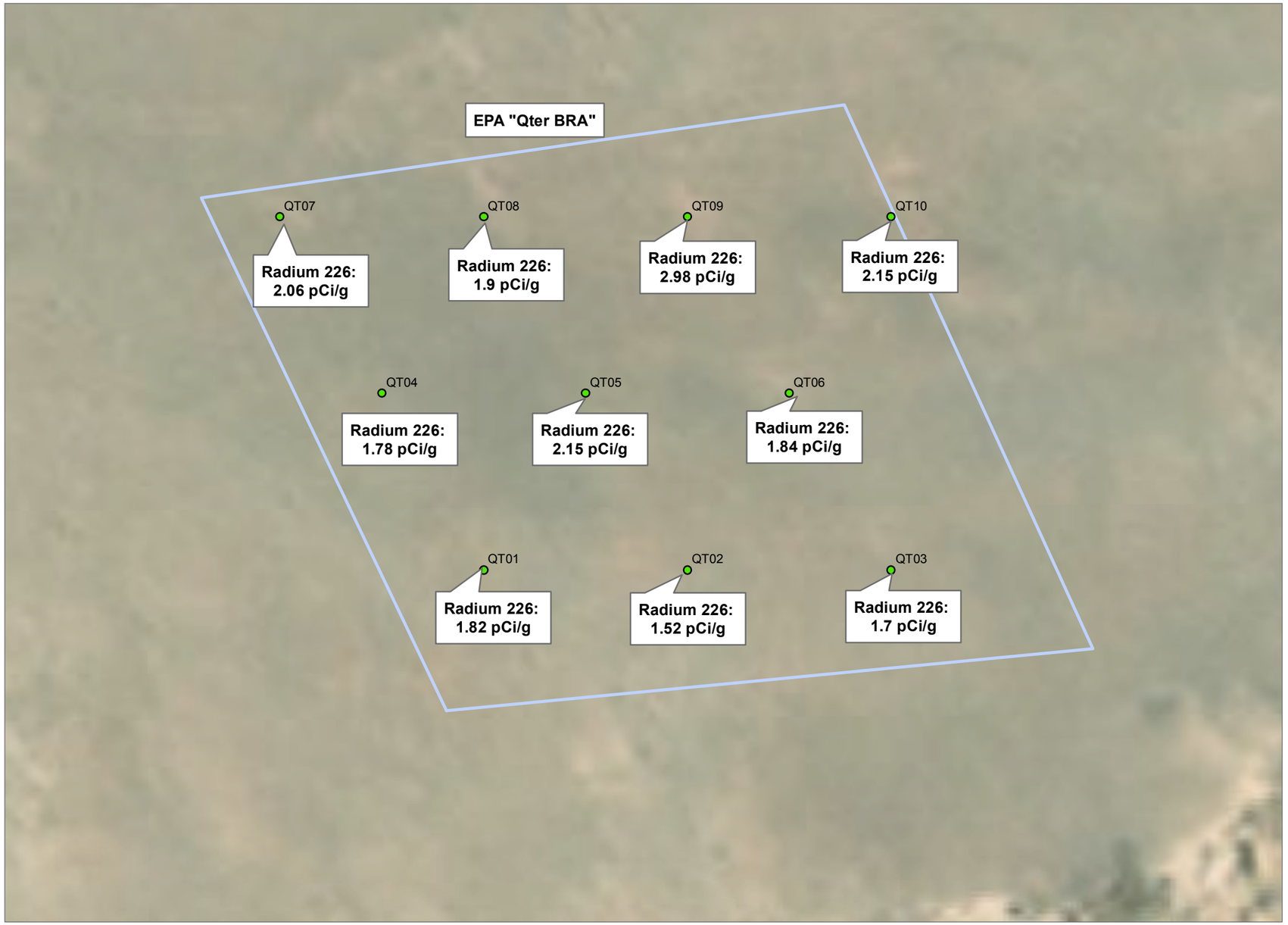
FIGURE 4-32
ALLUVIAL BSA #2 RADIUM-226 CONCENTRATIONS
BABBITT RANCHES



LEGEND

- Soil Sample Location
- EPA BRA Location
- Area of Potential Effect

N

0 15 30 60

Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 4-33 Radium EPA QTer.mxd Date Saved: March, 17, 2021

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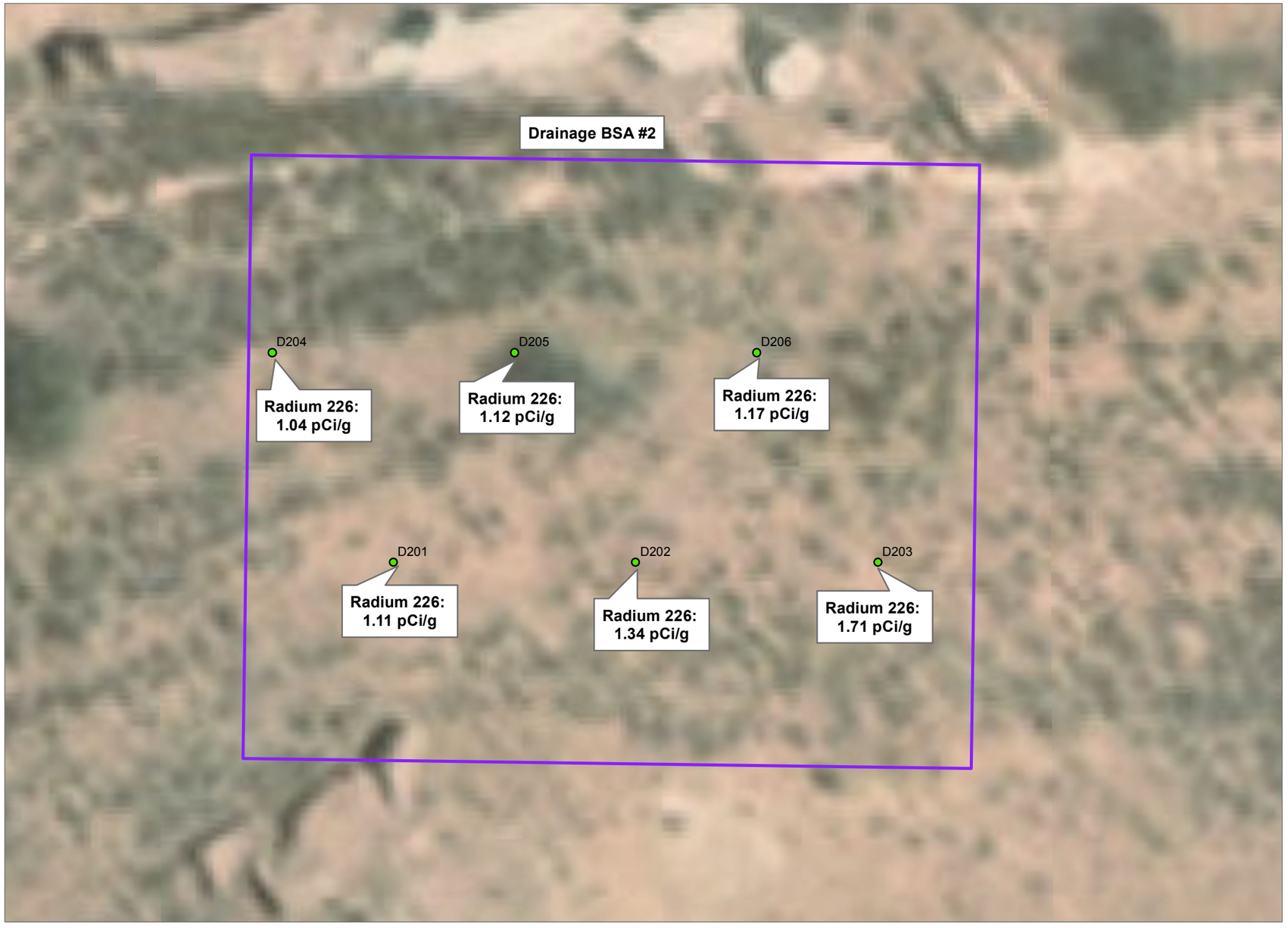
FIGURE 4-33
EPA QTer BRA RADIUM-226 CONCENTRATIONS
BABBITT RANCHES



LEGEND

- Soil Sample Location
- Babbitt BSA Locations
- Area of Potential Effect

N

0 15 30 60

Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mxd\Fig 4-34 Radium Drainage 2.mxd Date Saved: March, 17, 2021

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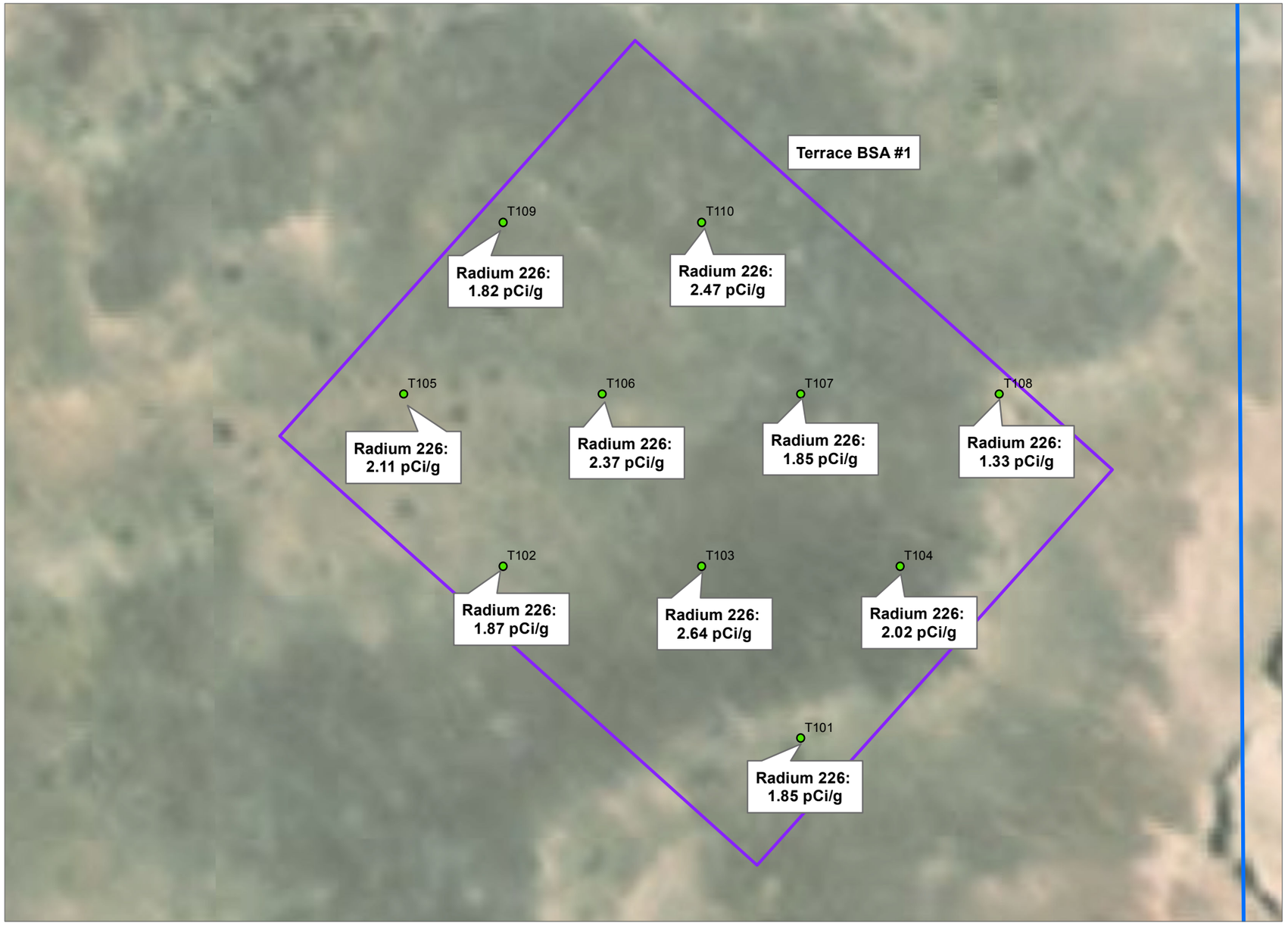
FIGURE 4-34
DRAINAGE BSA #2 RADIUM-226 CONCENTRATIONS
BABBITT RANCHES



LEGEND

- Soil Sample Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines

N

0 15 30 60

Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 4-35 Radium Terrace 1.mxd Date Saved: March, 17, 2021

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FIGURE 4-35
TERRACE BSA #1 RADIUM-226 CONCENTRATIONS
BABBITT RANCHES

LEGEND

- Soil Sample Location
- Babbitt BSA Locations
- Area of Potential Effect

N

0 15 30 60

Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 4-36 Radium LCR.mxd Date Saved: March. 17, 2021

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FIGURE 4-36
LITTLE COLORADO RIVER BSA RADIUM-226 CONCENTRATIONS
BABBITT RANCHES

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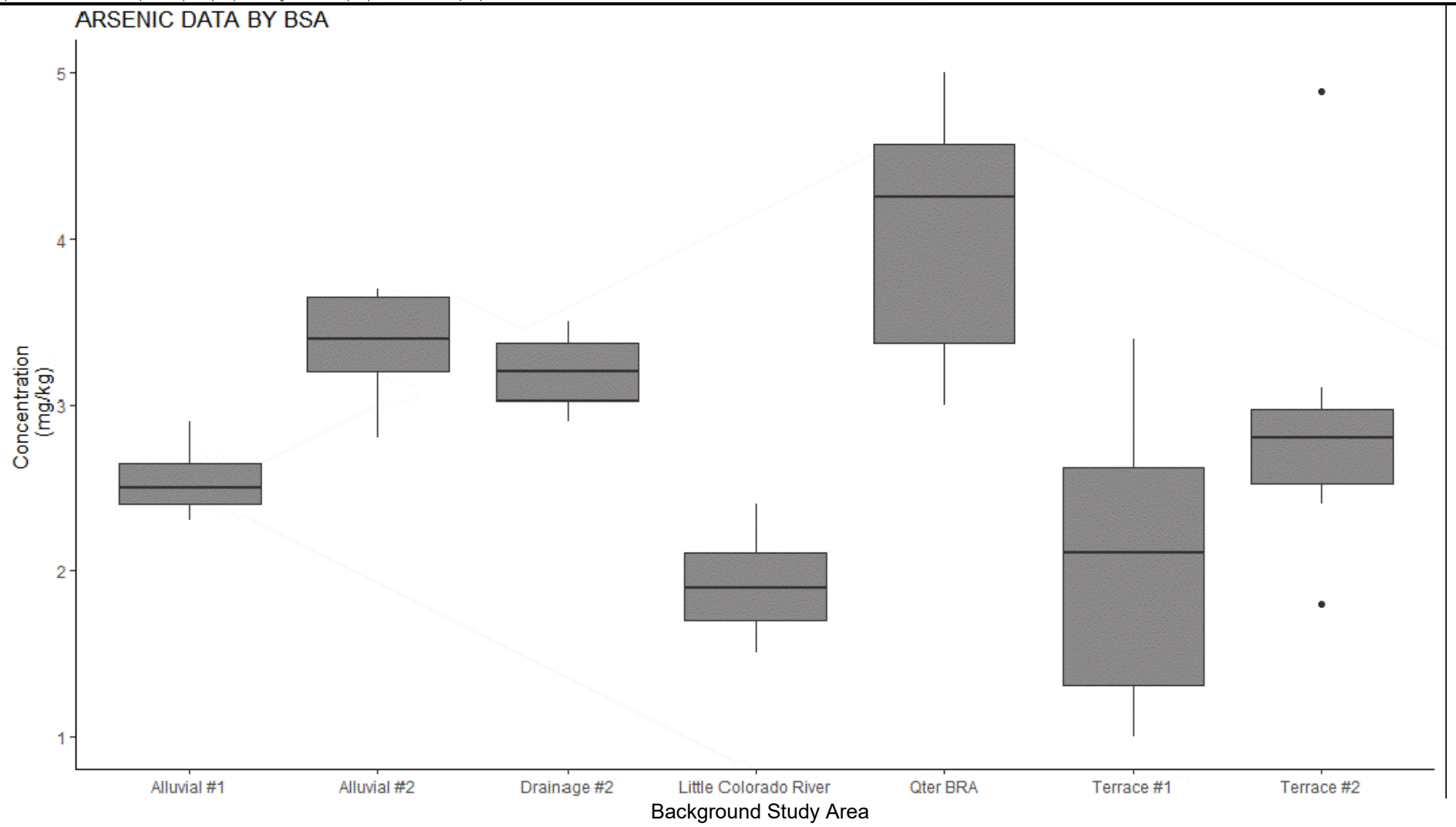

NOTE:
IN A TUKEY-STYLE BOXPLOT, BOXES REPRESENT THE 25th-75th PERCENTILES OF DATA AND DARK LINES THE MEDIAN.
POTENTIAL OUTLIERS ARE IDENTIFIED AS DOTS, WHILE WHISKERS SHOW THE RANGE OF THE REMAINDER OF THE DATA.

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FIGURE 4-37
BOXPLOT SHOWING SOIL CONCENTRATIONS OF ARSENIC BY BACKGROUND STUDY AREA
BABBITT RANCHES

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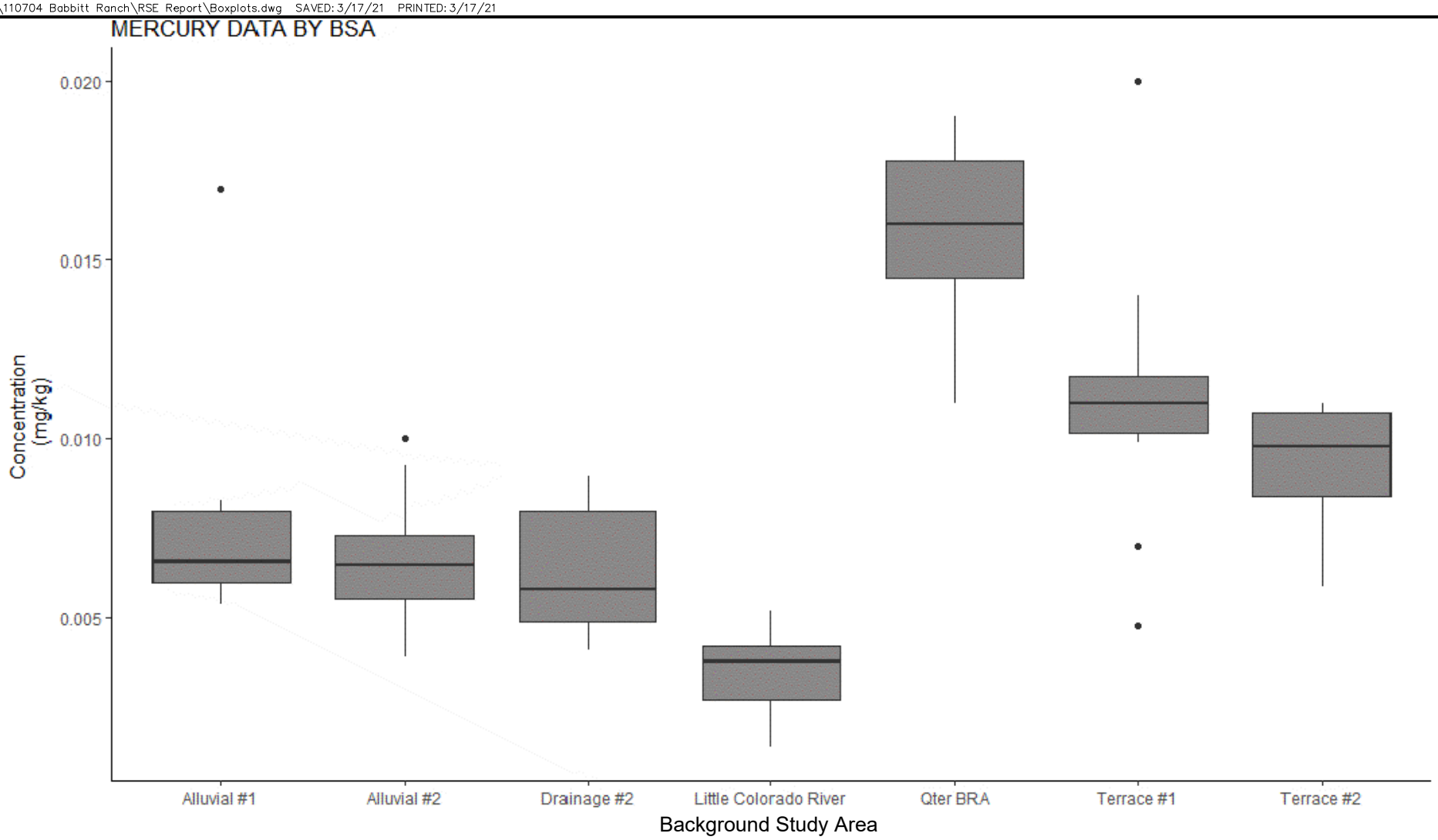

NOTE:
IN A TUKEY-STYLE BOXPLOT, BOXES REPRESENT THE 25th-75th PERCENTILES OF DATA AND DARK LINES THE MEDIAN. POTENTIAL OUTLIERS ARE IDENTIFIED AS DOTS, WHILE WHISKERS SHOW THE RANGE OF THE REMAINDER OF THE DATA.

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FIGURE 4-38
BOXPLOT SHOWING SOIL CONCENTRATIONS OF MERCURY BY BACKGROUND STUDY AREA
BABBITT RANCHES

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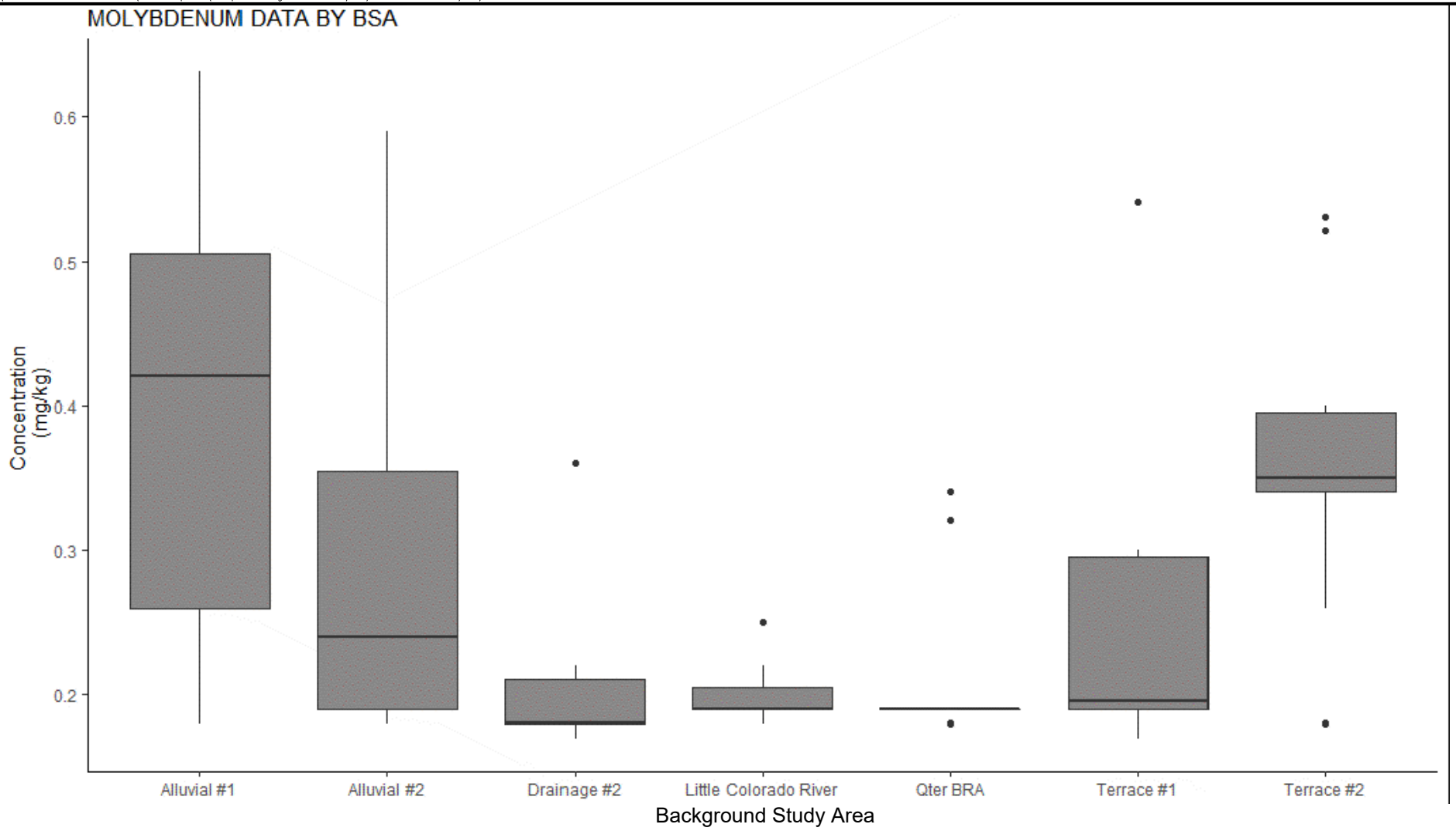

NOTE:
IN A TUKEY-STYLE BOXPLOT, BOXES REPRESENT THE 25th-75th PERCENTILES OF DATA AND DARK LINES THE MEDIAN. POTENTIAL OUTLIERS ARE IDENTIFIED AS DOTS, WHILE WHISKERS SHOW THE RANGE OF THE REMAINDER OF THE DATA.

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FIGURE 4-39
BOXPLOT SHOWING SOIL CONCENTRATIONS OF MOLYBDENUM BY BACKGROUND STUDY AREA
BABBITT RANCHES

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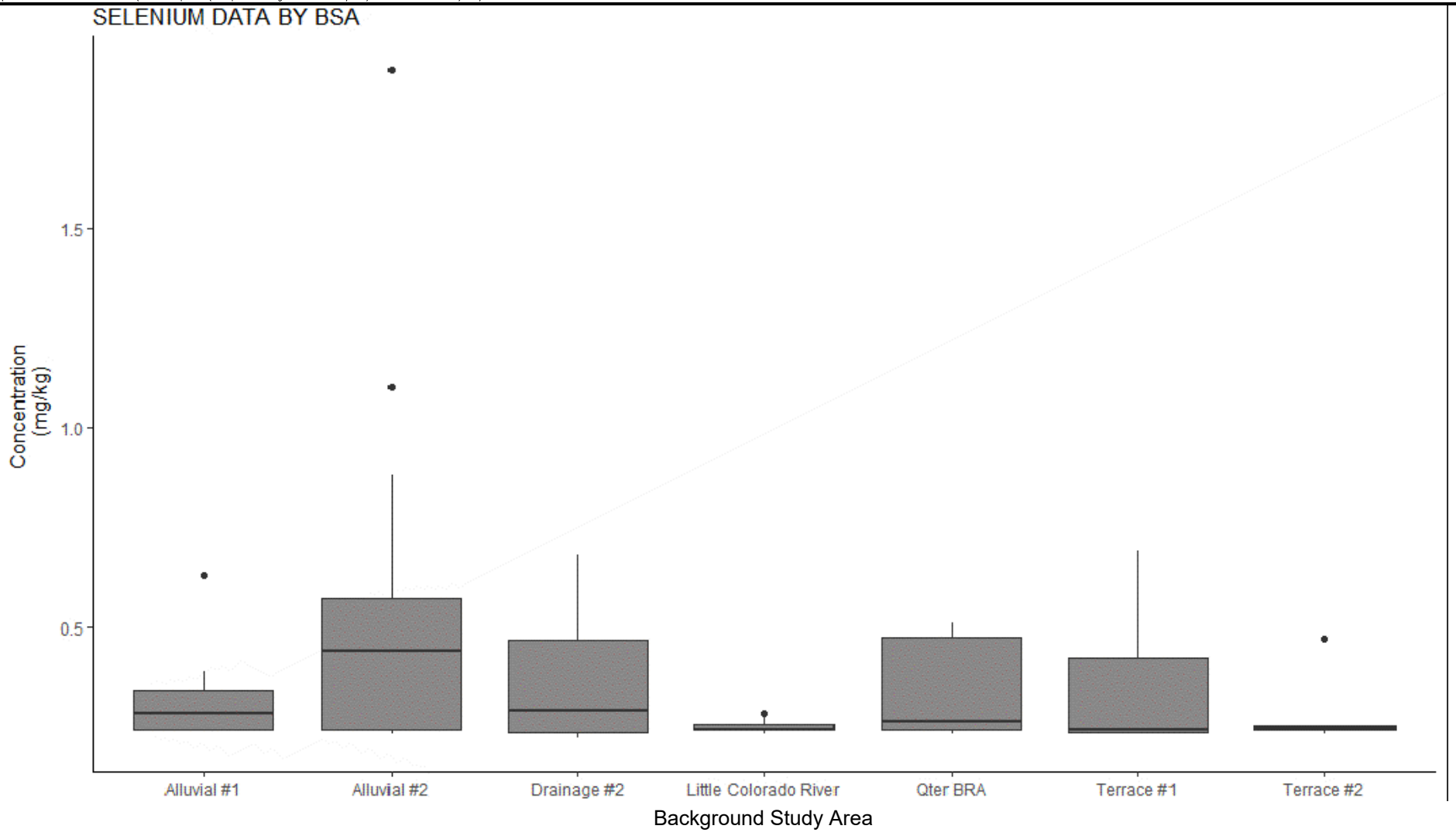

NOTE:
IN A TUKEY-STYLE BOXPLOT, BOXES REPRESENT THE 25th-75th PERCENTILES OF DATA AND DARK LINES THE MEDIAN.
POTENTIAL OUTLIERS ARE IDENTIFIED AS DOTS, WHILE WHISKERS SHOW THE RANGE OF THE REMAINDER OF THE DATA.

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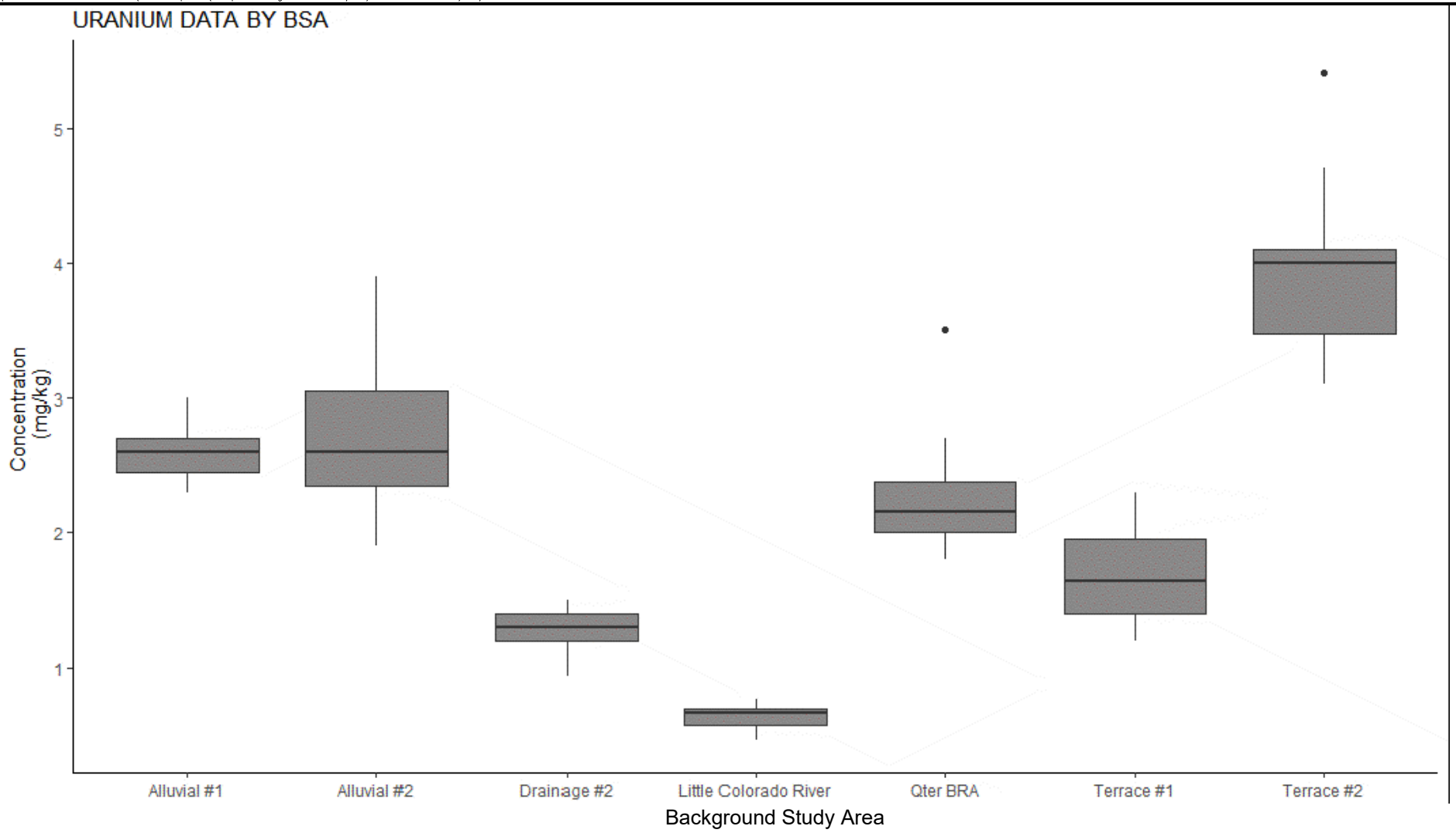
FIGURE 4-40
BOXPLOT SHOWING SOIL CONCENTRATIONS OF SELENIUM BY BACKGROUND STUDY AREA
BABBITT RANCHES

T:\110704 Babbitt Ranch\RSE Report\Boxplots.dwg SAVED: 3/17/21 PRINTED: 3/17/21



NOTE:
IN A TUKEY-STYLE BOXPLOT, BOXES REPRESENT THE 25th-75th PERCENTILES OF DATA AND DARK LINES THE MEDIAN. POTENTIAL OUTLIERS ARE IDENTIFIED AS DOTS, WHILE WHISKERS SHOW THE RANGE OF THE REMAINDER OF THE DATA.

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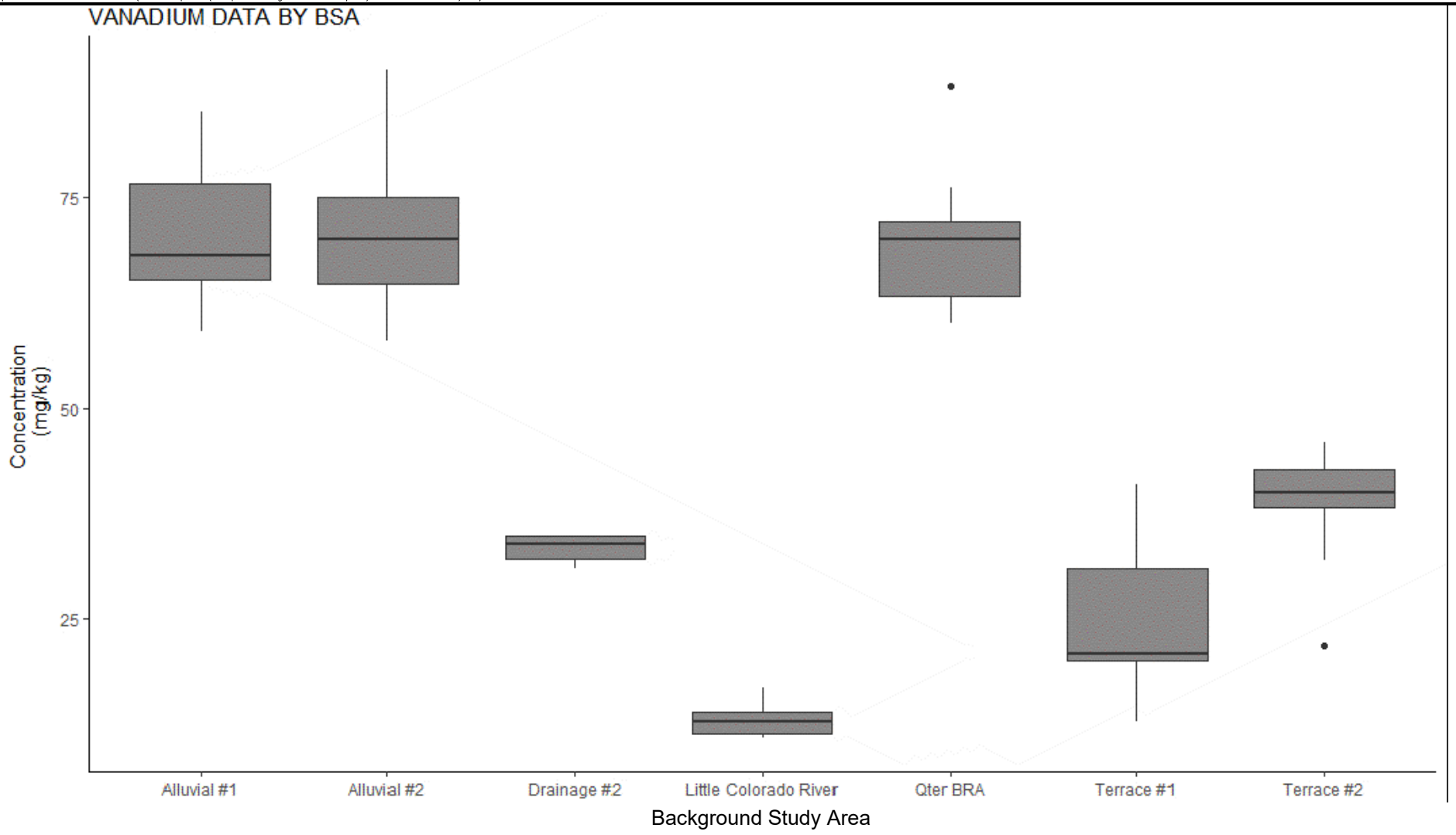
FIGURE 4-41
BOXPLOT SHOWING SOIL CONCENTRATIONS OF URANIUM BY BACKGROUND STUDY AREA
BABBITT RANCHES

T:\110704 Babbitt Ranch\RSE Report\Boxplots.dwg SAVED: 3/17/21 PRINTED: 3/17/21



NOTE:
IN A TUKEY-STYLE BOXPLOT, BOXES REPRESENT THE 25th-75th PERCENTILES OF DATA AND DARK LINES THE MEDIAN. POTENTIAL OUTLIERS ARE IDENTIFIED AS DOTS, WHILE WHISKERS SHOW THE RANGE OF THE REMAINDER OF THE DATA.

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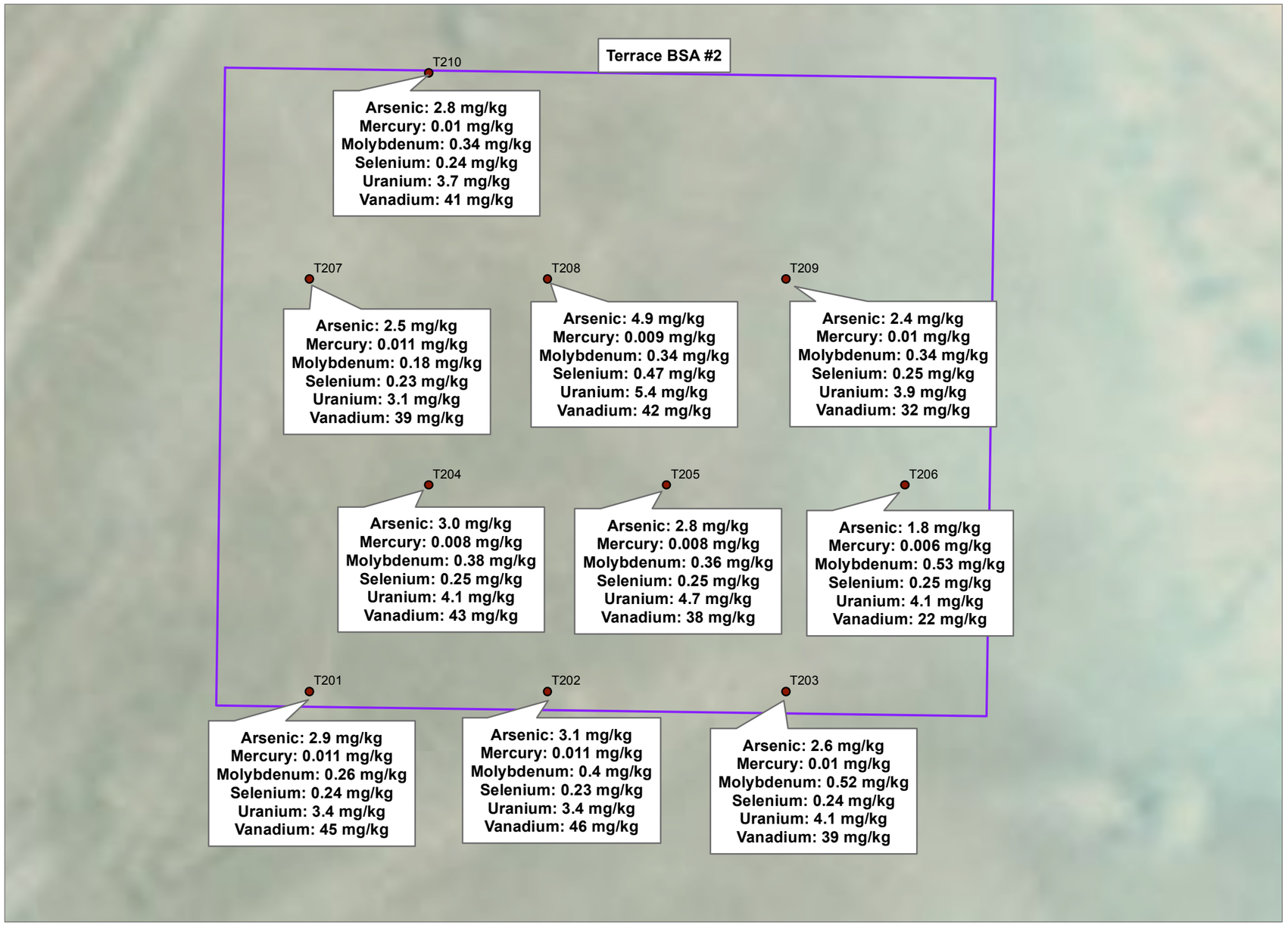
FIGURE 4-42
BOXPLOT SHOWING SOIL CONCENTRATIONS OF VANADIUM BY BACKGROUND STUDY AREA
BABBITT RANCHES



LEGEND

- Soil Sample Location
- Babbitt BSA Locations

N

0 12.5 25 50

Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 4-43 Metals Terrace 2.mxd Date Saved: March, 17, 2021

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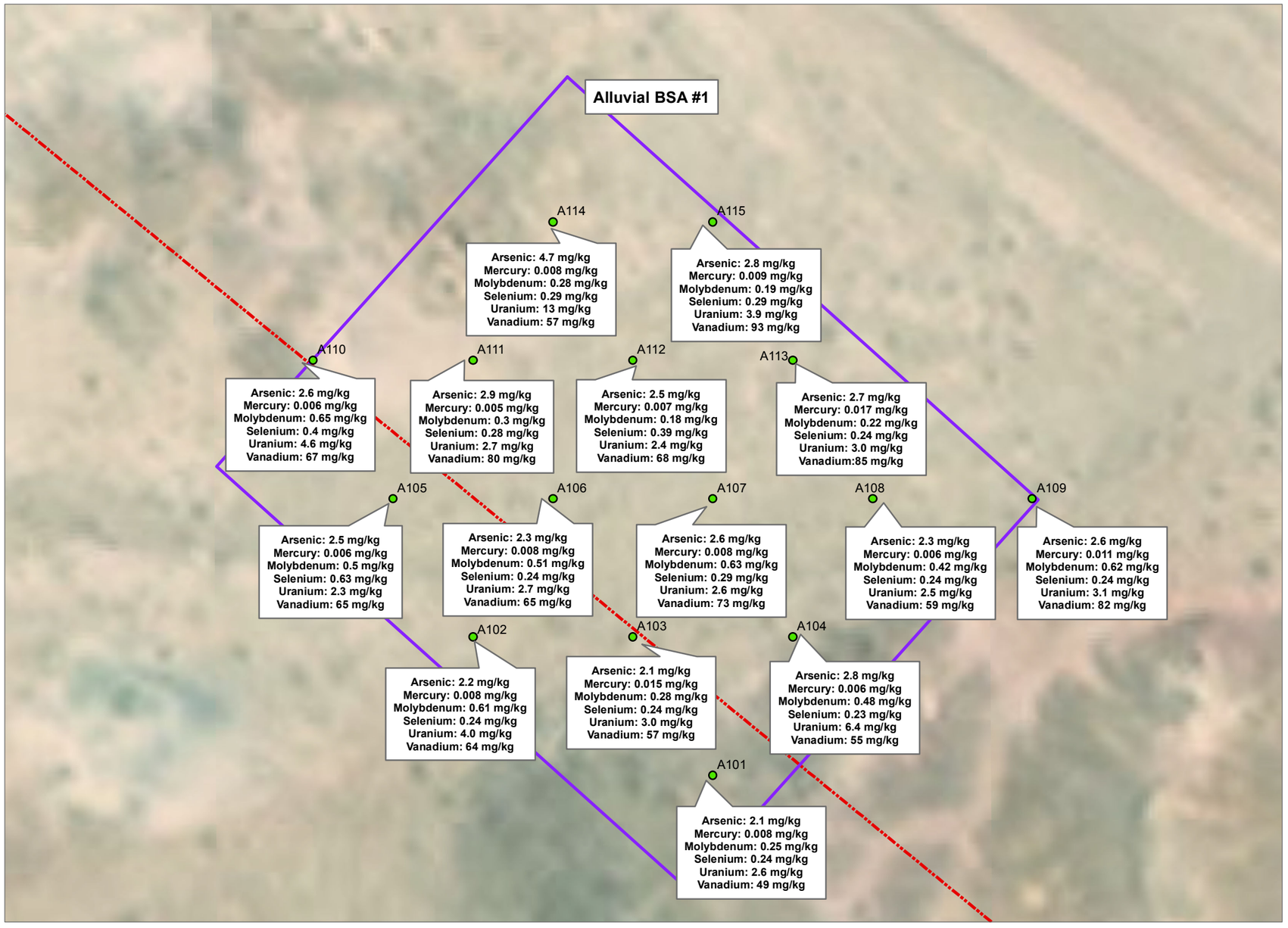
FIGURE 4-43
TERRACE BSA #2 METALS CONCENTRATIONS
BABBITT RANCHES



LEGEND

- Soil Sample Location
- Babbitt BSA Locations
- Area of Potential Effect

N

0 15 30 60

Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 4-44 Metals Alluvial 1.mxd Date Saved: March, 17, 2021

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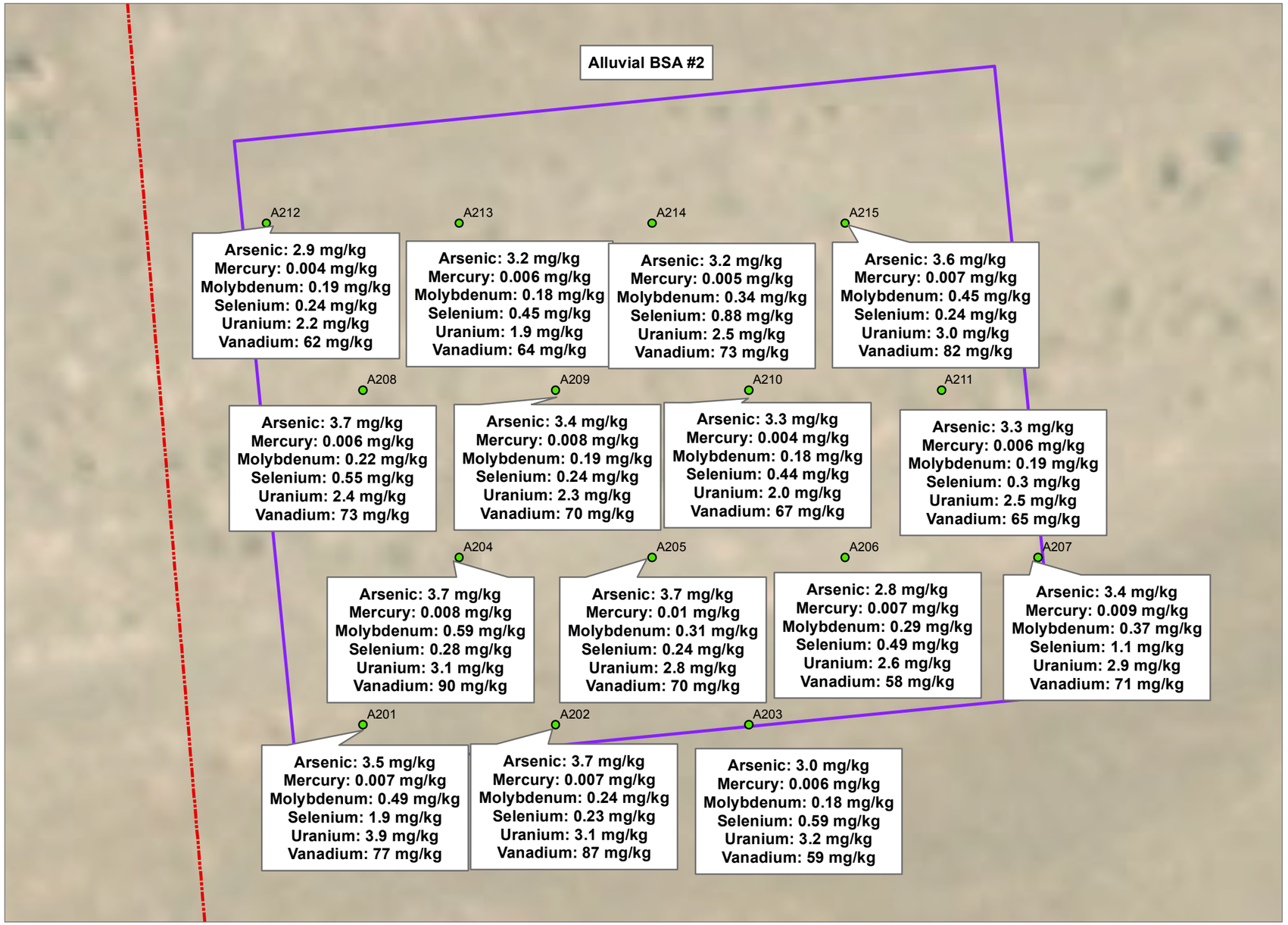
FIGURE 4-44
ALLUVIAL BSA #1 METALS CONCENTRATIONS
BABBITT RANCHES



LEGEND

- Soil Sample Location
- Babbitt BSA Locations
- Area of Potential Effect

N

0 12.5 25 50

Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 4-45 Metals Alluvial 2.mxd Date Saved: March, 17, 2021

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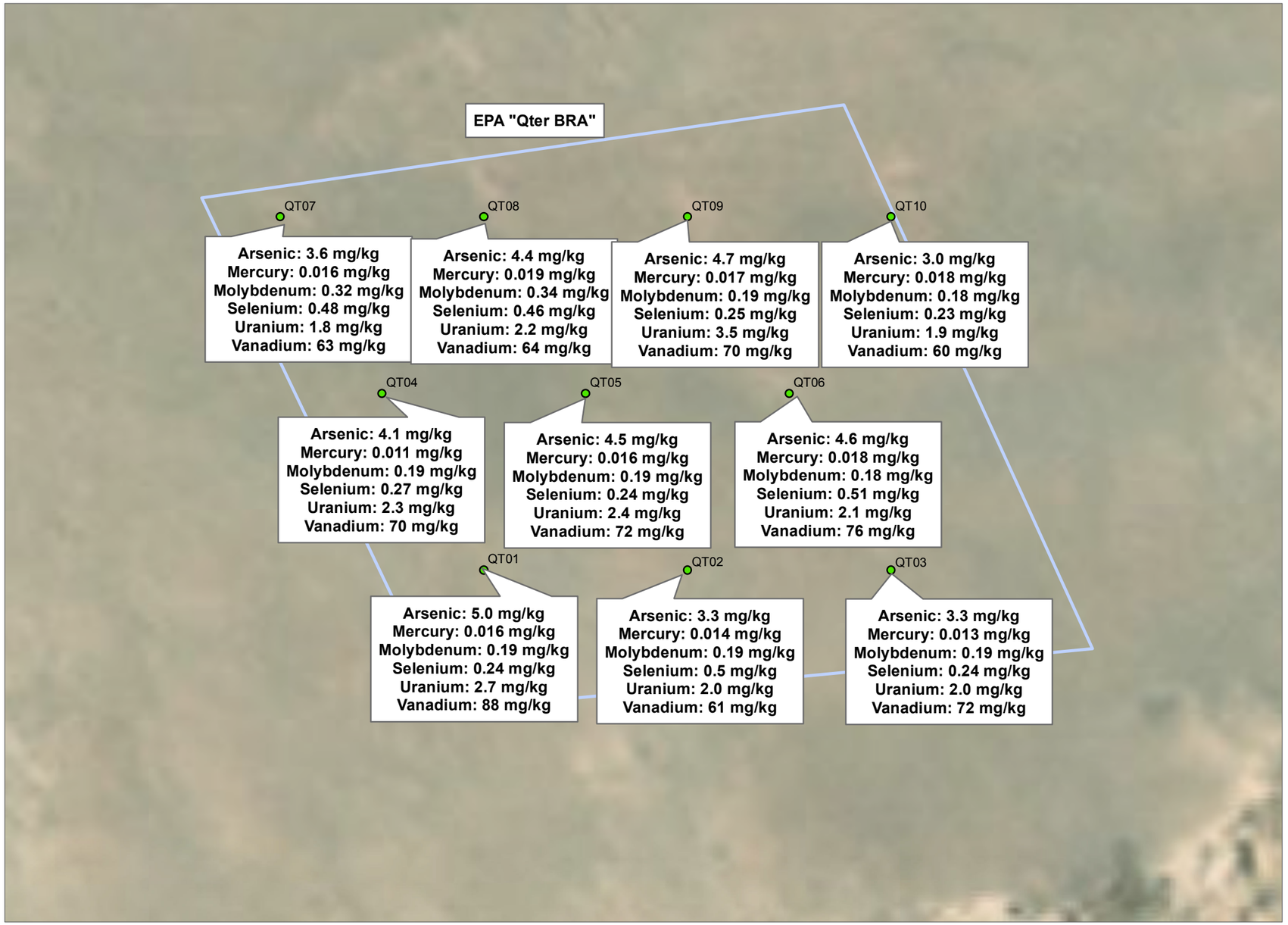
FIGURE 4-45
ALLUVIAL BSA #2 METALS CONCENTRATIONS
BABBITT RANCHES



T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mxd\Fig 4-46 Metals EPA QTer.mxd Date Saved: March, 17, 2021

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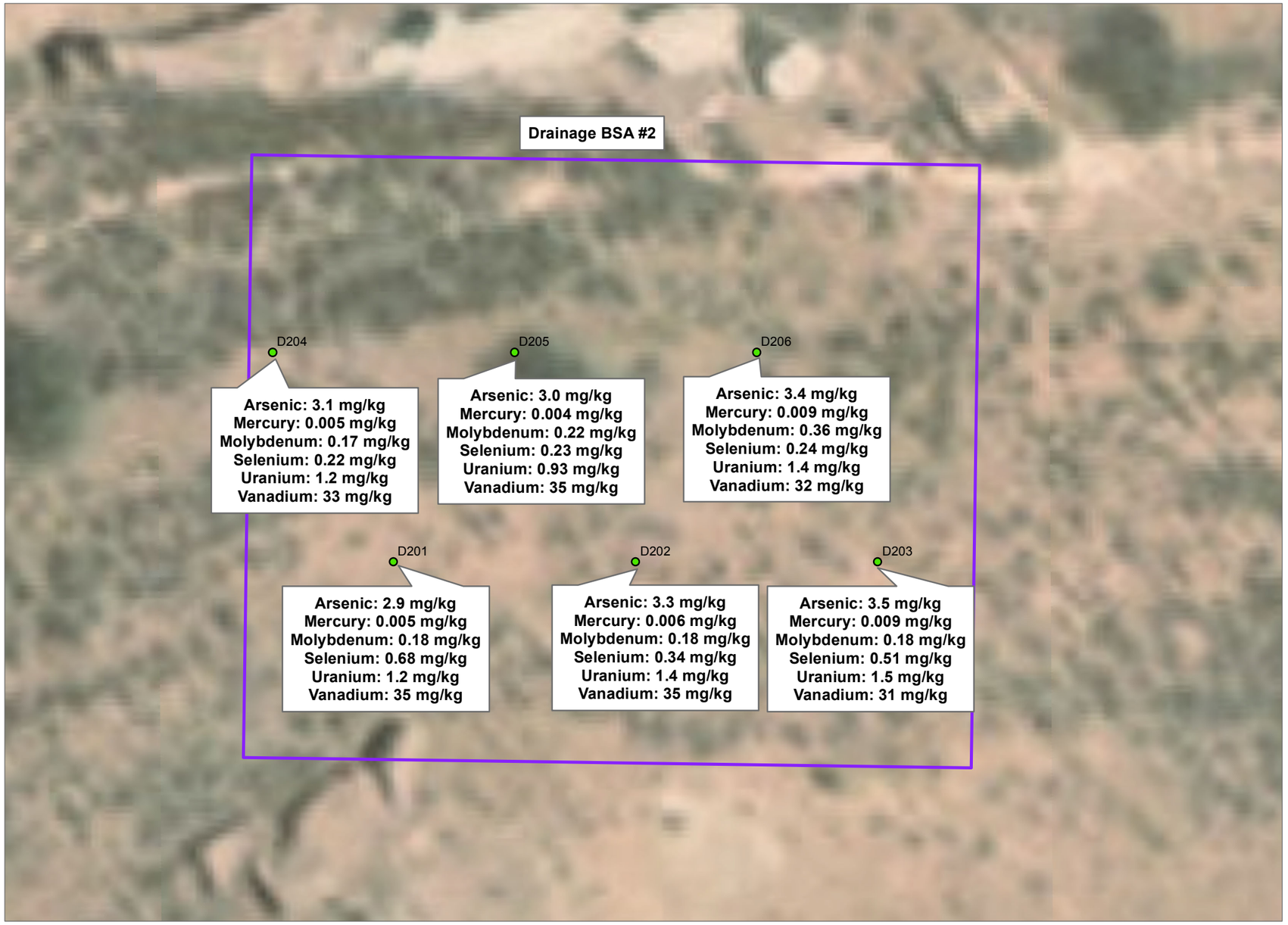
FIGURE 4-46
EPA QTer BRA METALS CONCENTRATIONS
BABBITT RANCHES



LEGEND

- Soil Sample Location
- Babbitt BSA Locations
- Area of Potential Effect

N

0 15 30 60

Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 4-47 Metals Drainage 2.mxd Date Saved: March, 17, 2021

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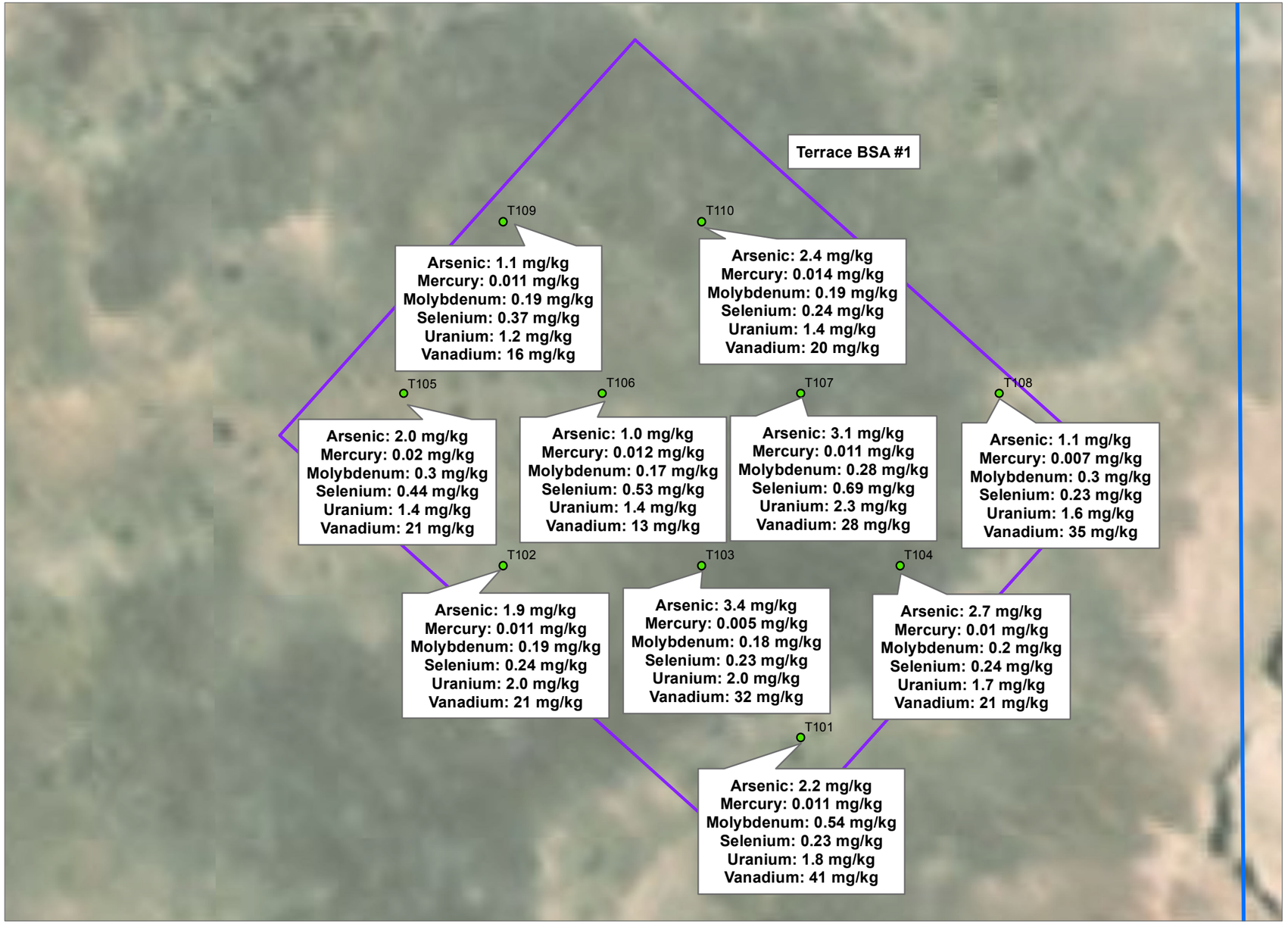
FIGURE 4-47
DRAINAGE BSA #2 METALS CONCENTRATIONS
BABBITT RANCHES



LEGEND

- Soil Sample Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines

N

0 15 30 60

Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 4-48 Metals Terrace 1.mxd Date Saved: March, 17, 2021

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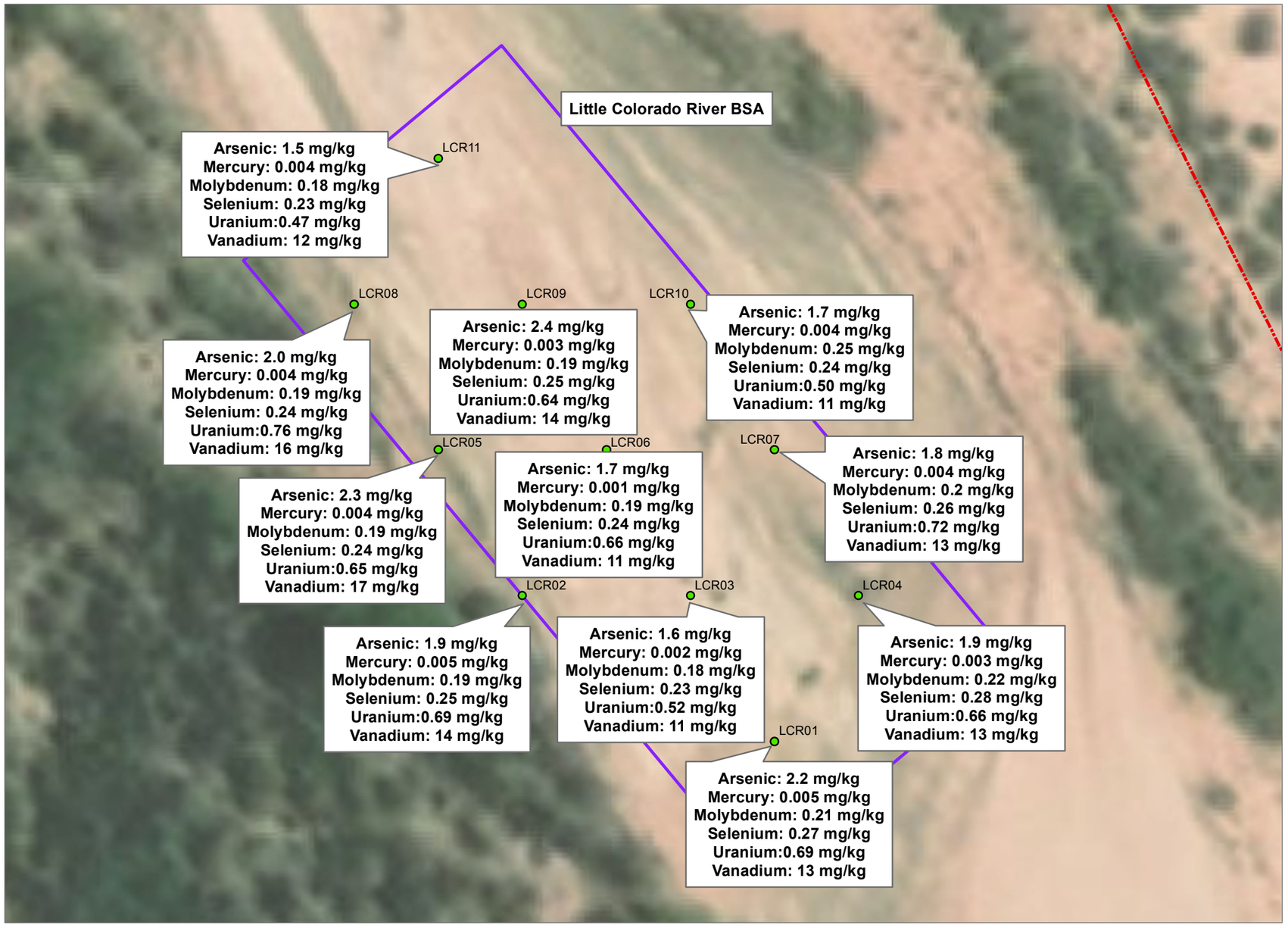
FIGURE 4-48
TERRACE BSA #1 METALS CONCENTRATIONS
BABBITT RANCHES



T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 4-49 Metals LCR.mxd Date Saved: March, 17, 2021

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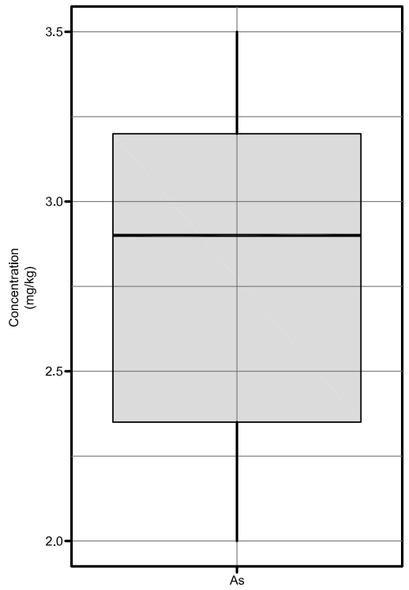
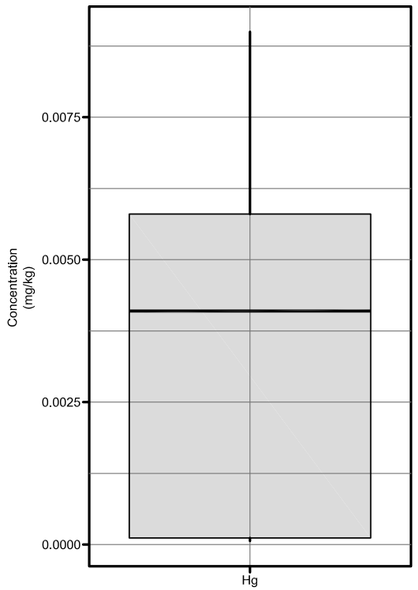
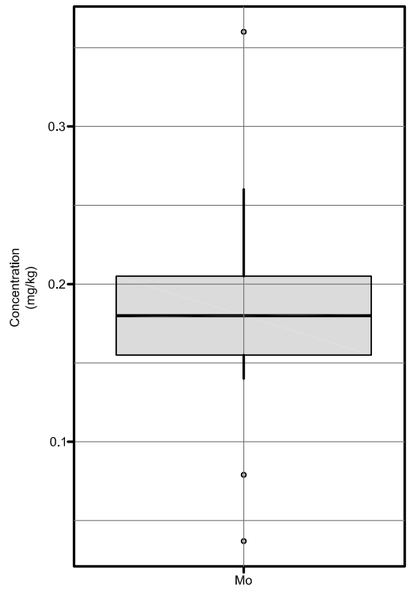
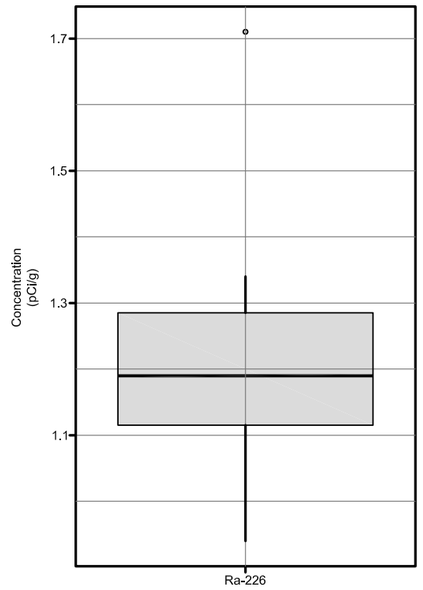
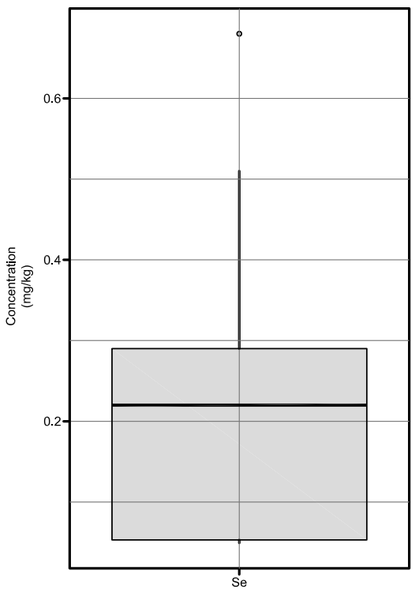
FIGURE 4-49
LITTLE COLORADO RIVER BSA METALS CONCENTRATIONS
BABBITT RANCHES

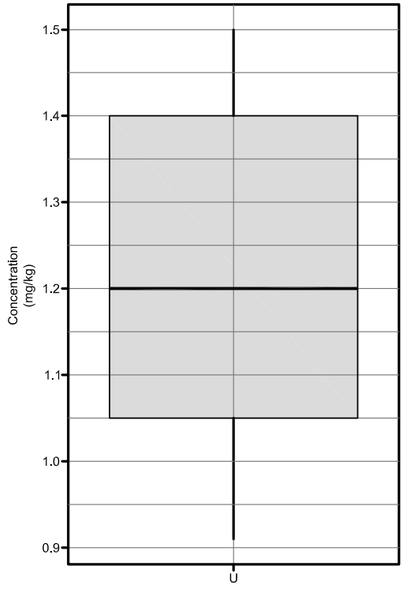


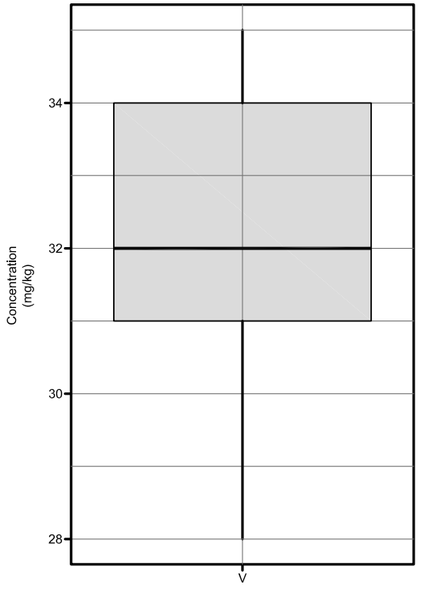












NOTE:
IN A TUKEY-STYLE BOXPLOT, BOXES REPRESENT THE 25th -75th PERCENTILES OF DATA AND DARK LINE THE MEDIAN, POTENTIAL OUTLIERS ARE IDENTIFIED AS DOTS, WHILE WHISKERS SHOW THE RANGE OF THE REMAINDER OF THE DATA.

T:\110704 Babbitt Ranch\RSE Report\Boxplot 17.dwg SAVED: 3/17/21 PRINTED: 3/17/21

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FIGURE 4-50
BOXPLOT SHOWING SOIL ACTIVITY AND CONCENTRATIONS FOR DRAINAGE BSA #2
BABBITT RANCHES

T:\110704 Babbitt Ranch\RSE Report\Boxplots.dwg SAVED: 3/17/21 PRINTED: 3/17/21

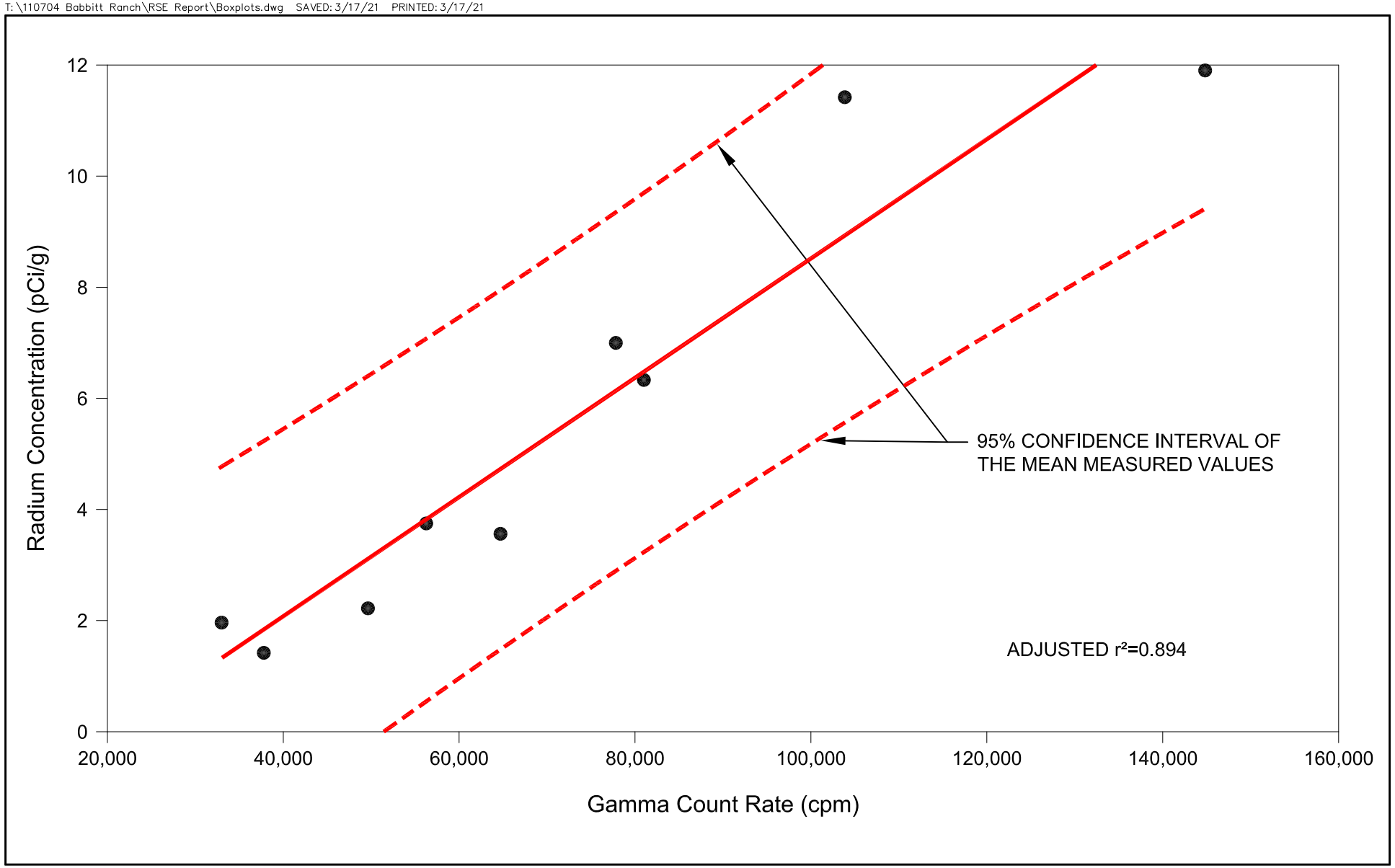

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FIGURE 5-1
CORRELATION BETWEEN HORIZONTAL GAMMA SURVEY CORRELATION DATA AND SOIL RADIUM ACTIVITY CONCENTRATION
BABBITT RANCHES

T:\110704 Babbitt Ranch\RSE Report\Boxplots.dwg SAVED: 3/17/21 PRINTED: 3/17/21

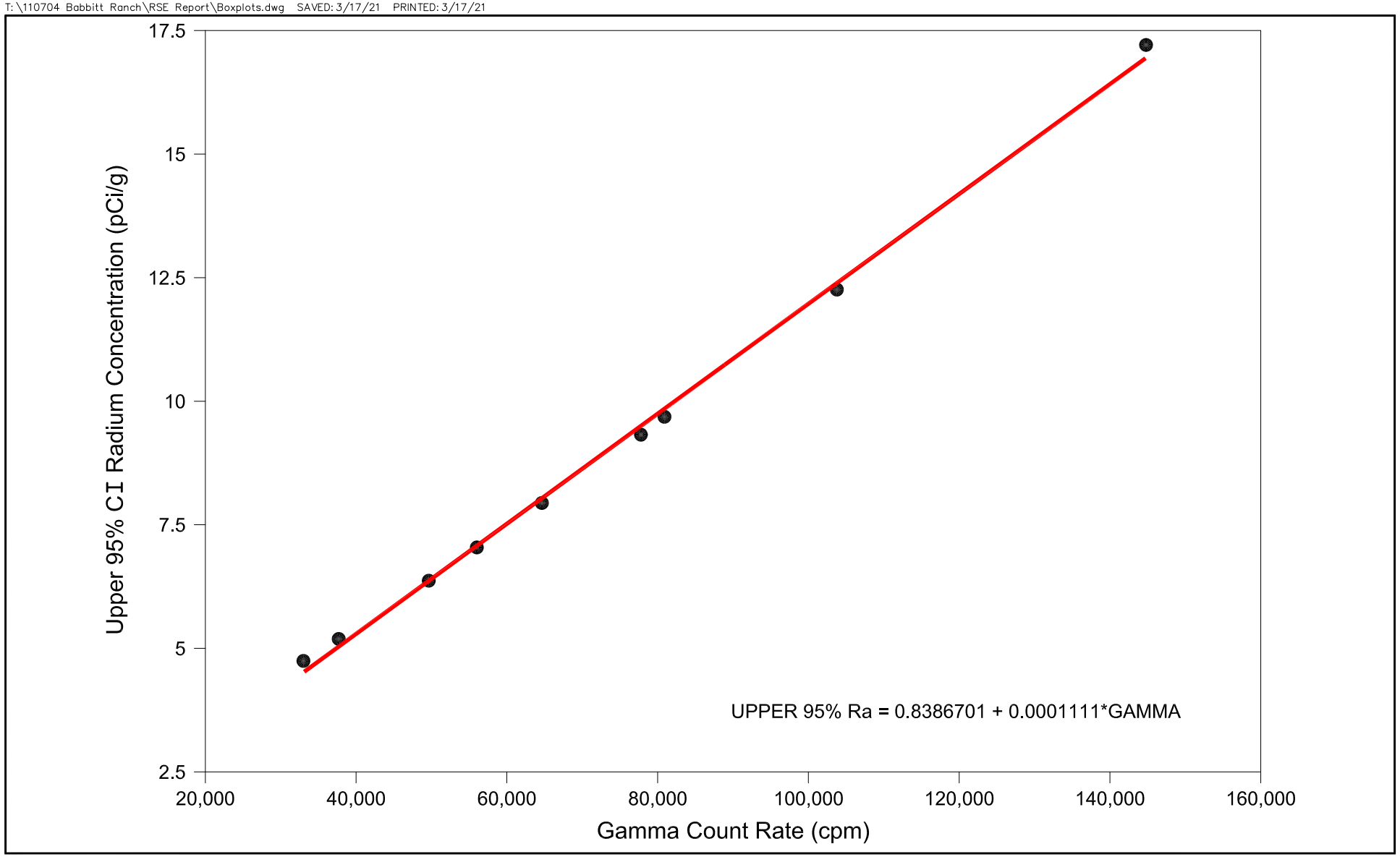

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FIGURE 5-2
CORRELATION BETWEEN THE UPPER 95% CONFIDENCE INTERVAL OF THE MEAN HORIZONTAL GAMMA SURVEY RESPONSE AND SOIL RADIUM ACTIVITY CONCENTRATION
BABBITT RANCHES

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T:\110704 Babbitt Ranch\RSE Report\Boxplots.dwg SAVED: 3/17/21 PRINTED: 3/17/21

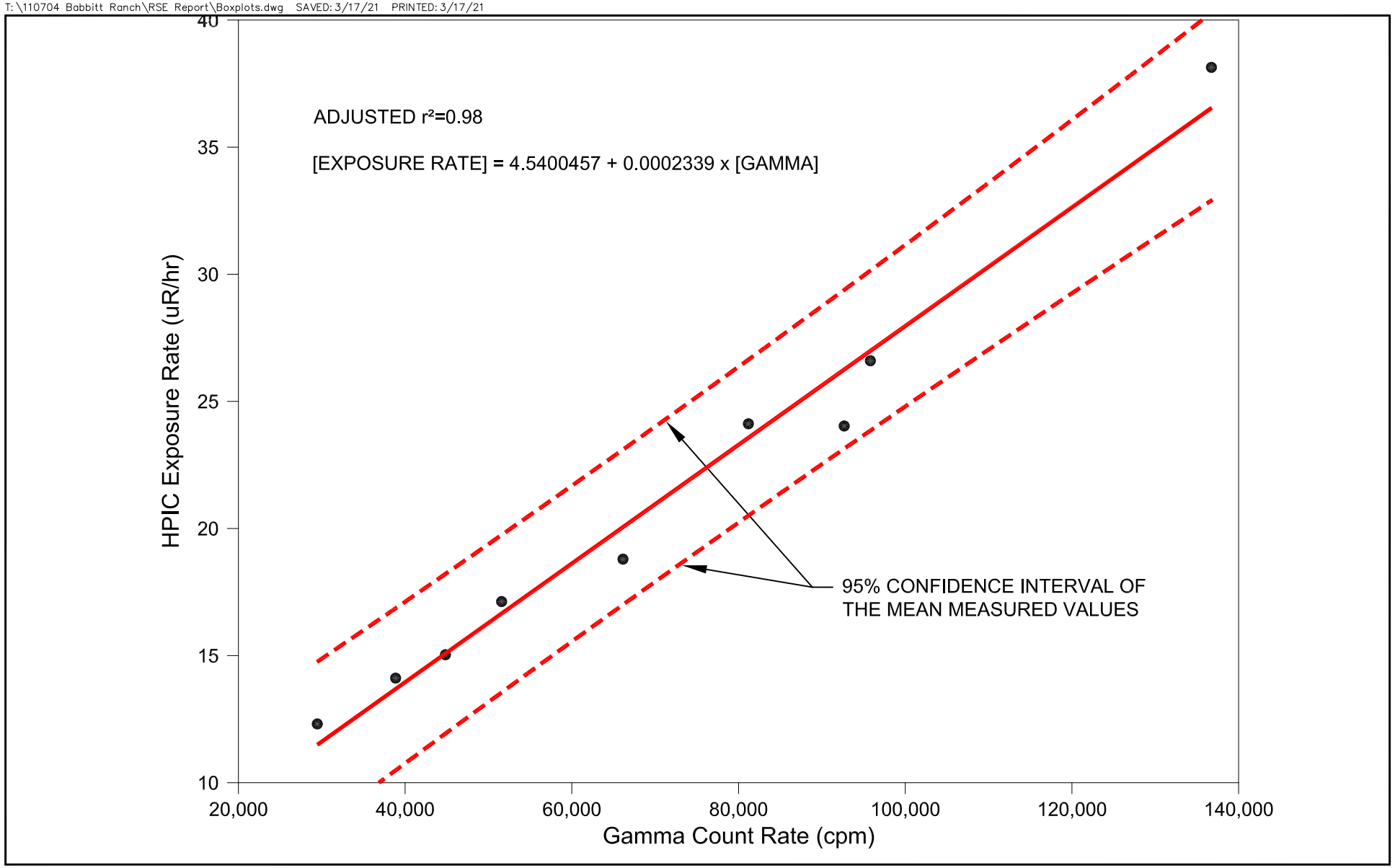

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FIGURE 5-3
CORRELATION BETWEEN HIGH-PRESSURIZED ION CHAMBER EXPOSURE RATE AND MEAN VERTICAL GAMMA SURVEY RESPONSE
BABBITT RANCHES

T: \110704 Babbitt Ranch\RSE Report\Boxplots.dwg SAVED: 3/17/21 PRINTED: 3/17/21

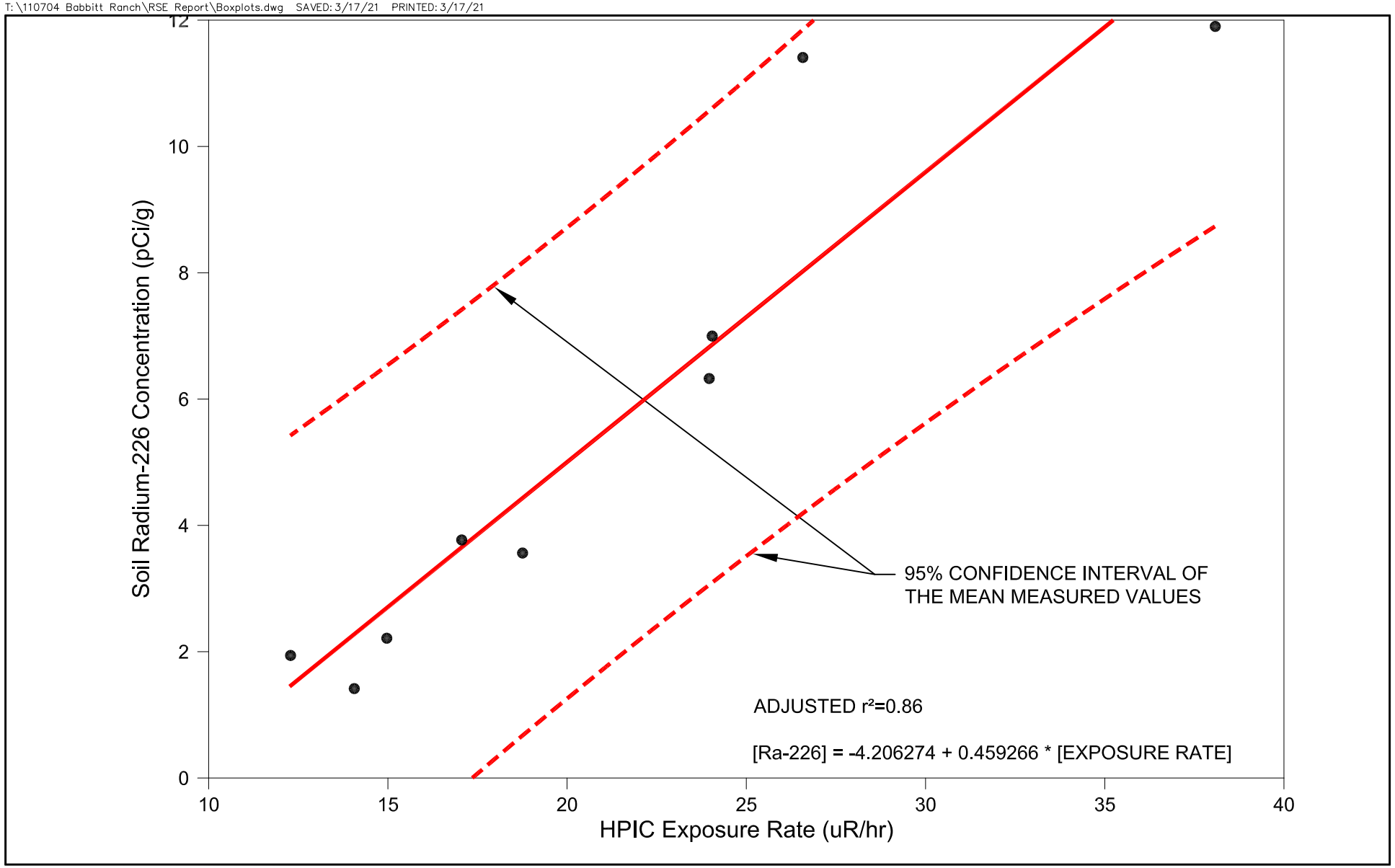

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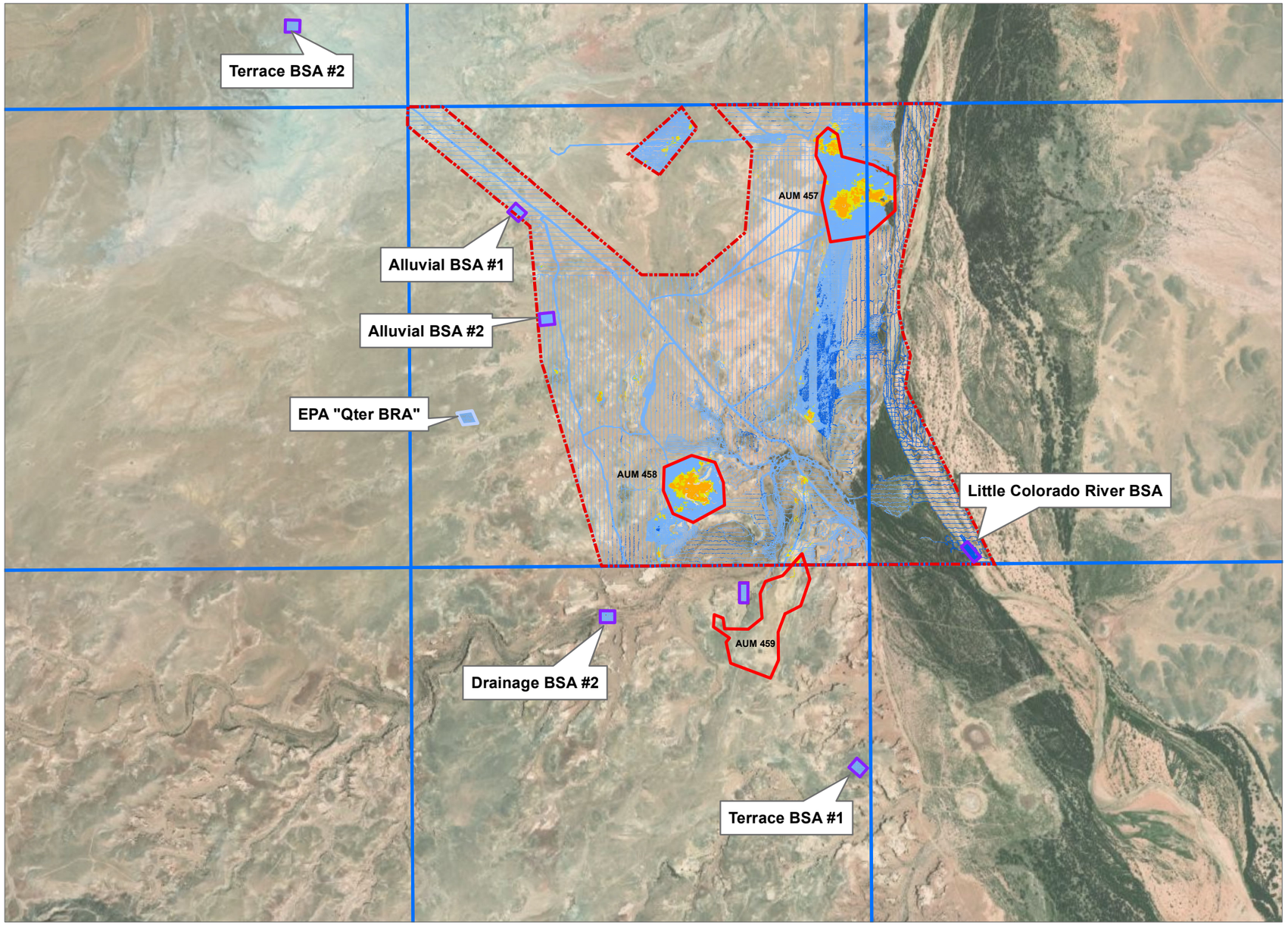
FIGURE 5-4
CORRELATION BETWEEN SOIL RADIUM-226 ACTIVITY CONCENTRATION AND HIGH-PRESSURIZED ION CHAMBER EXPOSURE RATE
BABBITT RANCHES



LEGEND

- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary

Exposure Rate (uR/hr)

- <4.5
- 4.5 - 9.9
- 9.9 - 16.9
- >16.9

NOTES:
1. For display purposes only.
2. Exposure rate calculated from walkover gamma data using the mean regression result.
3. Exposure [uR/hr] = 4.5400457+0.0002339*Gamma

0 0.125 0.25 0.5 Miles

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 5-5 Gamma Exposure.mxd Date Saved: March, 17, 2021

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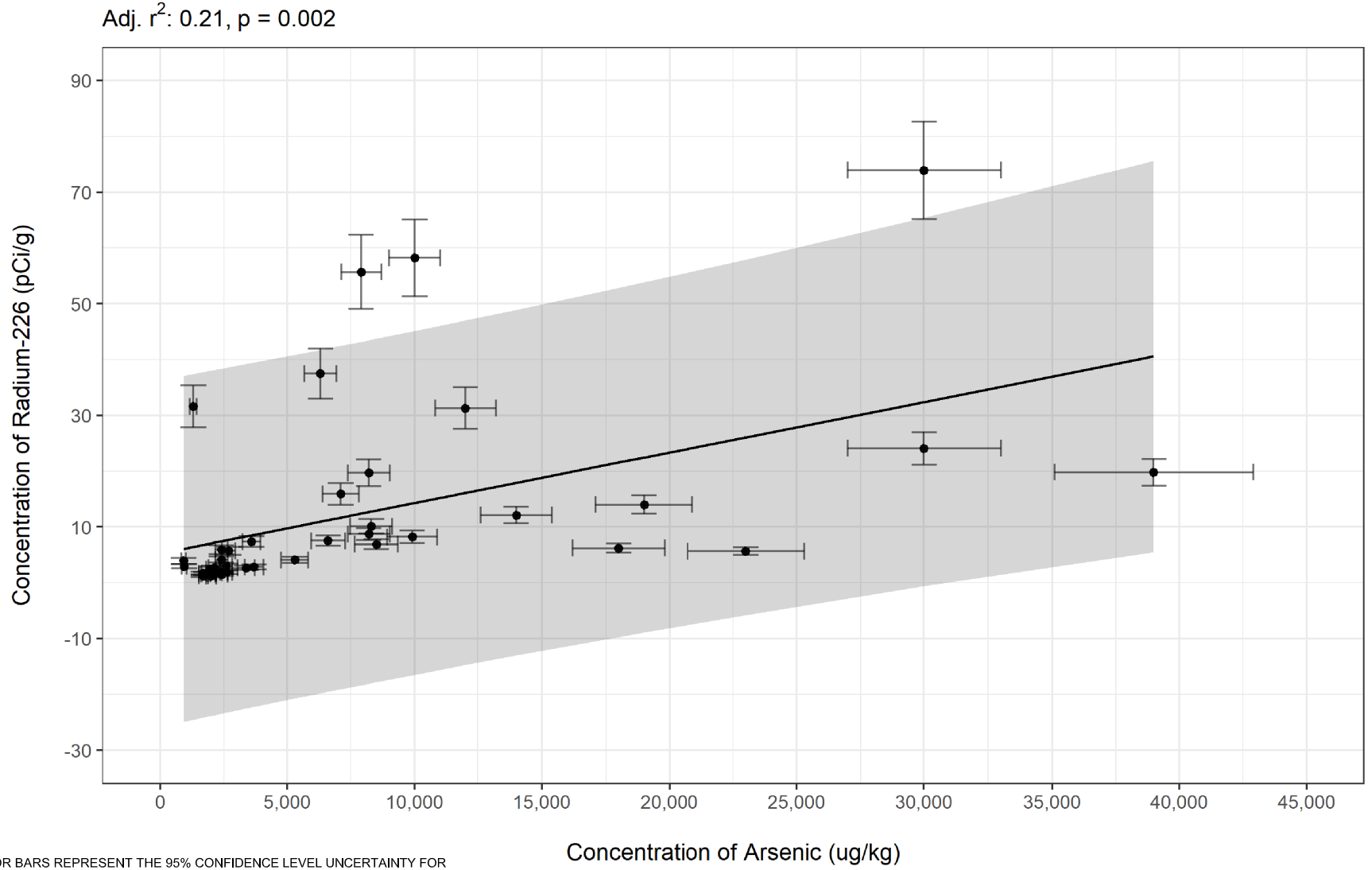
FIGURE 5-5
EXPOSURE RATE FOR THE ENTIRE APE
BABBITT RANCHES

T:\110704 Babbitt Ranch\RSE Report\Correlation Figs.dwg SAVED: 3/17/21 PRINTED: 3/17/21



NOTE:
1) ERROR BARS REPRESENT THE 95% CONFIDENCE LEVEL UNCERTAINTY FOR RADIONUCLIDES AND ± 20% FOR METALS. THE GREY BANDED REGION REPRESENTS THE 95% PREDICTION INTERVAL OF THE REGRESSION MODEL.

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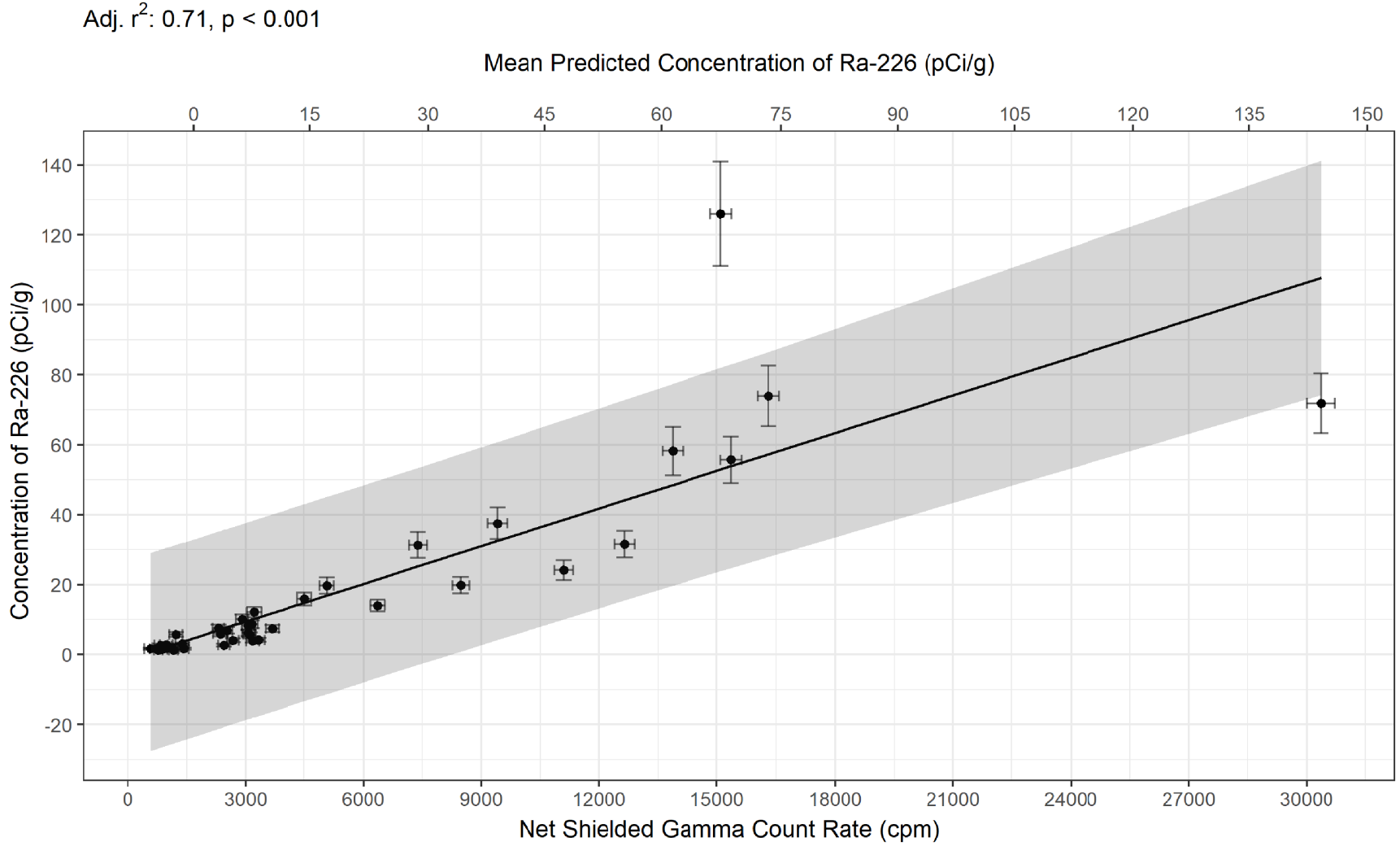
FIGURE 5-6
CORRELATION BETWEEN RADIUM-226 AND ARSENIC
BABBITT RANCHES



NOTE:
1) ERROR BARS REPRESENT THE 95% CONFIDENCE LEVEL UNCERTAINTY FOR RADIONUCLIDES AND ± 20% FOR METALS. THE GREY BANDED REGION REPRESENTS THE 95% PREDICTION INTERVAL OF THE REGRESSION MODEL.
2) A 2-INCH BY 2-INCH NaI DETECTOR WAS USED TO COLLECT GAMMA DATA.

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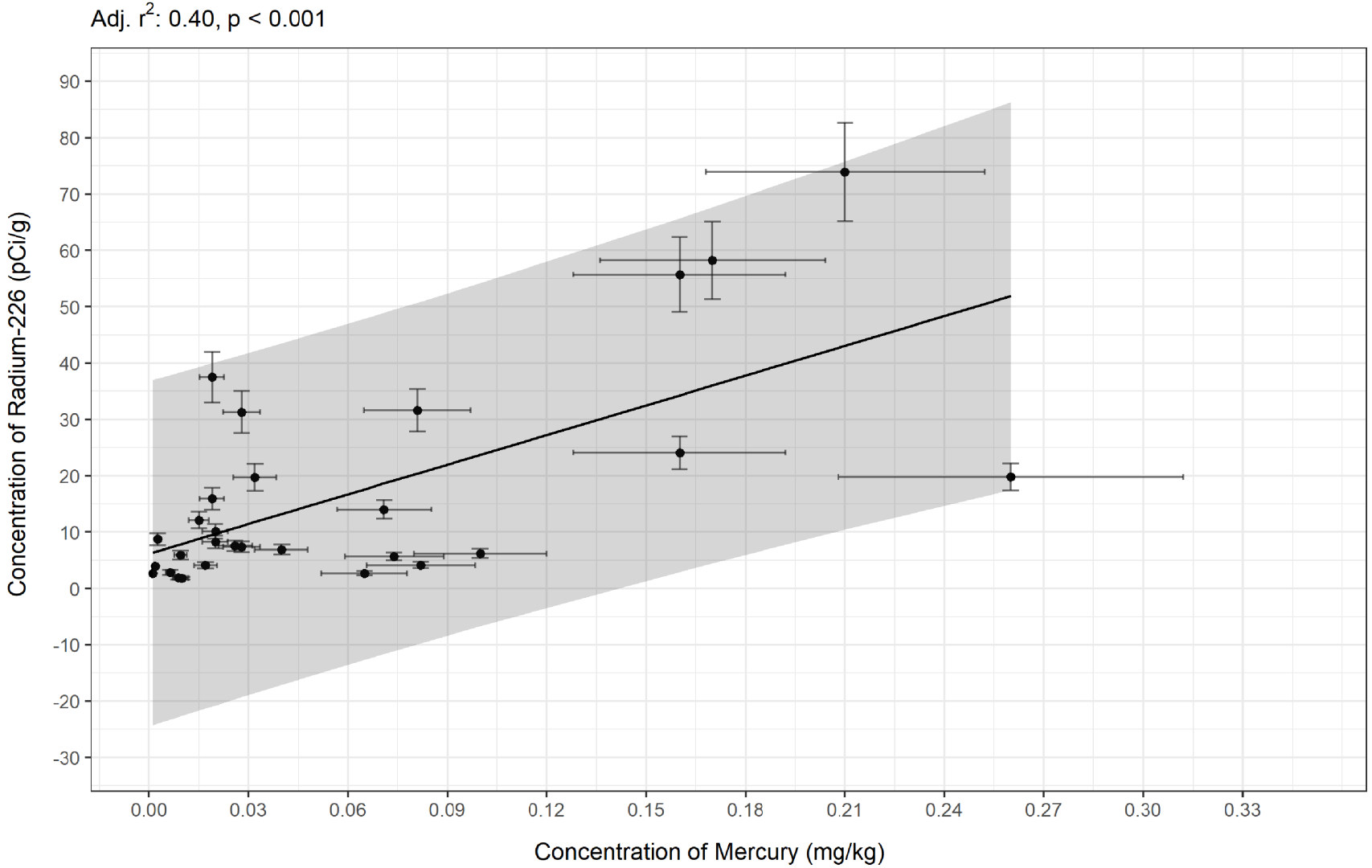
FIGURE 5-7
CORRELATION BETWEEN RADIUM-226 AND GAMMA COUNT RATE
BABBITT RANCHES



NOTE:
1) ERROR BARS REPRESENT THE 95% CONFIDENCE LEVEL UNCERTAINTY FOR RADIONUCLIDES AND ± 20% FOR METALS. THE GREY BANDED REGION REPRESENTS THE 95% PREDICTION INTERVAL OF THE REGRESSION MODEL.

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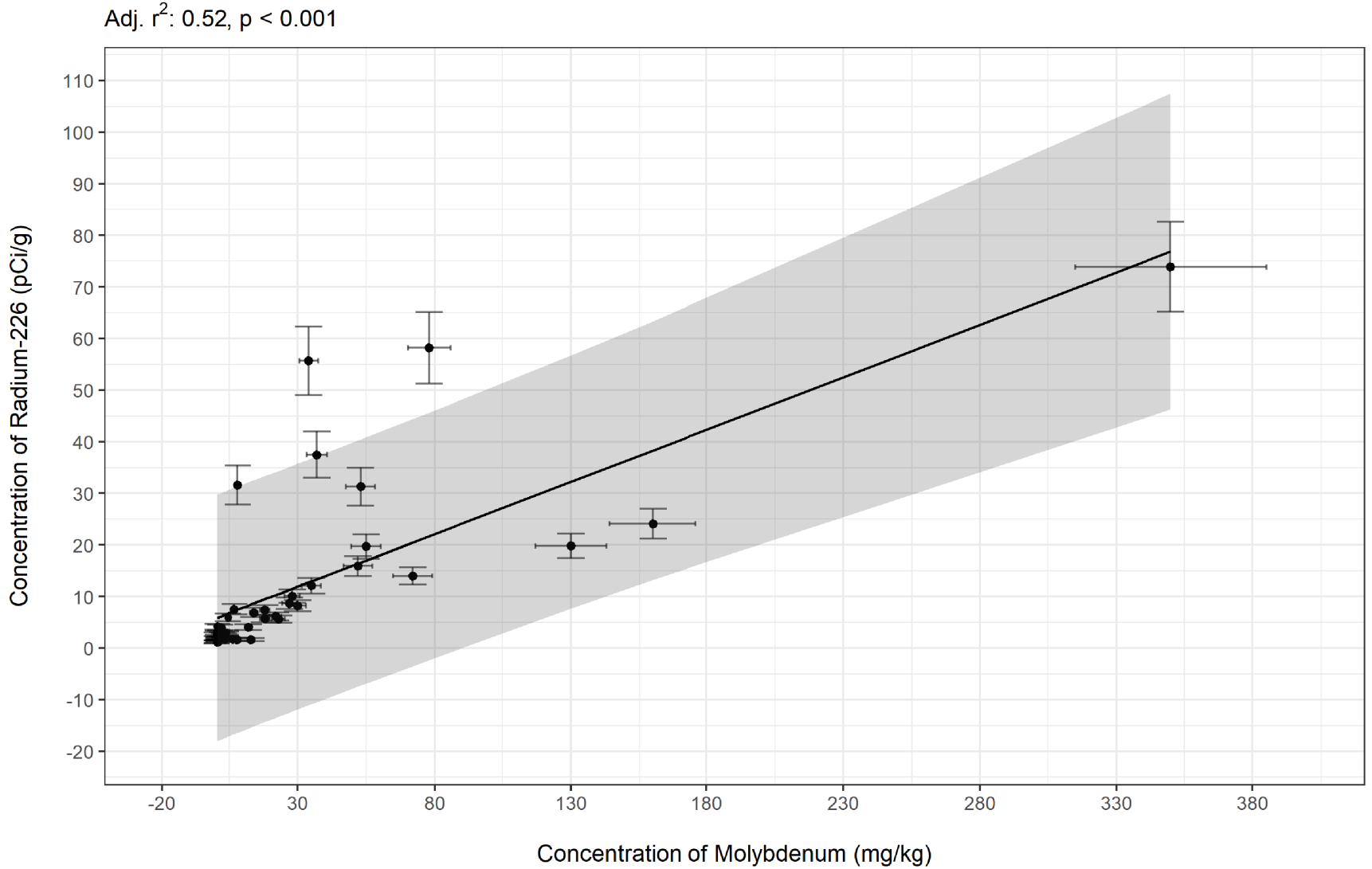
FIGURE 5-8
CORRELATION BETWEEN RADIUM-226 AND MERCURY
BABBITT RANCHES



NOTE:
1) ERROR BARS REPRESENT THE 95% CONFIDENCE LEVEL UNCERTAINTY FOR RADIONUCLIDES AND ± 20% FOR METALS. THE GREY BANDED REGION REPRESENTS THE 95% PREDICTION INTERVAL OF THE REGRESSION MODEL.

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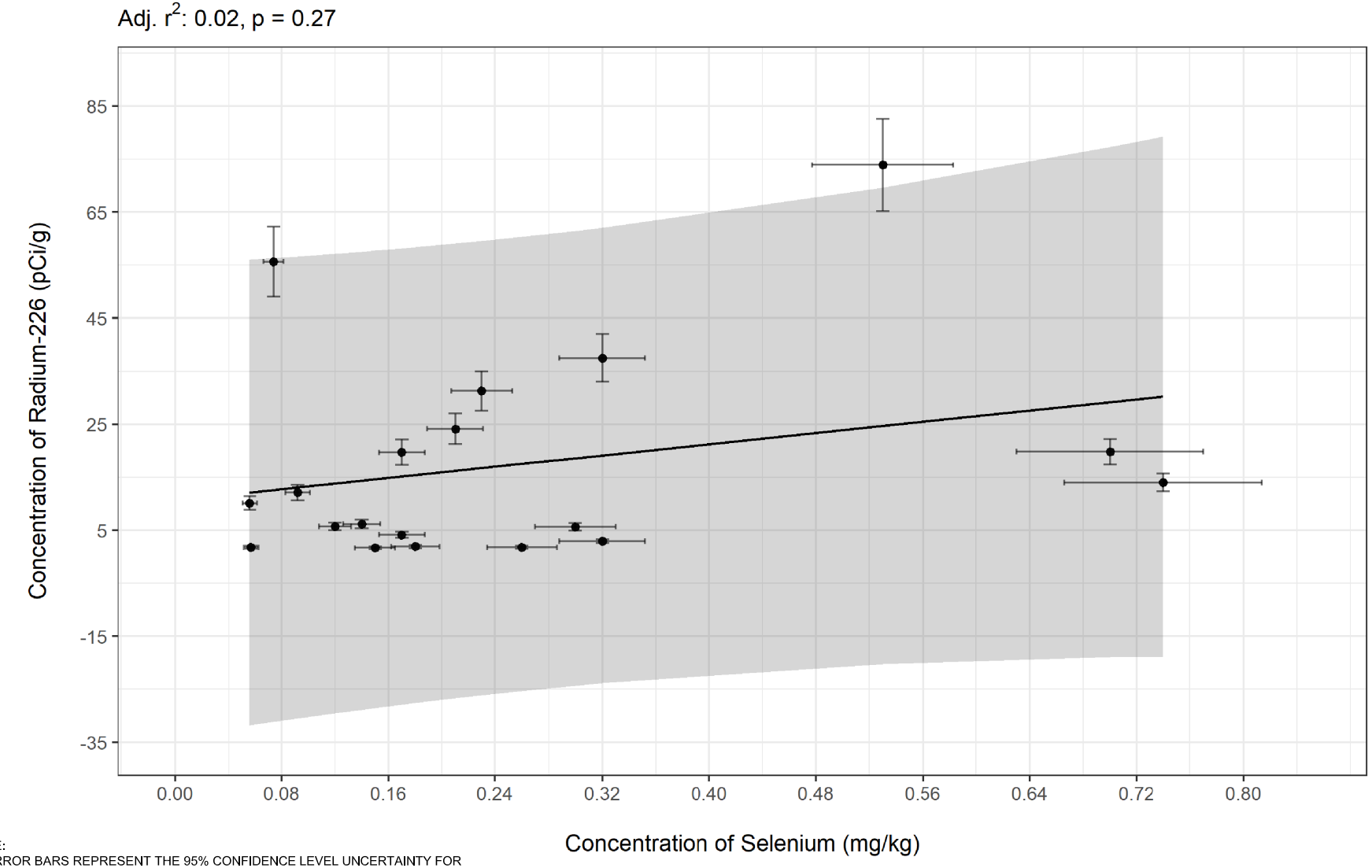
FIGURE 5-9
CORRELATION BETWEEN RADIUM-226 AND MOLYBDENUM
BABBITT RANCHES



NOTE:
1) ERROR BARS REPRESENT THE 95% CONFIDENCE LEVEL UNCERTAINTY FOR RADIONUCLIDES AND ± 20% FOR METALS. THE GREY BANDED REGION REPRESENTS THE 95% PREDICTION INTERVAL OF THE REGRESSION MODEL.

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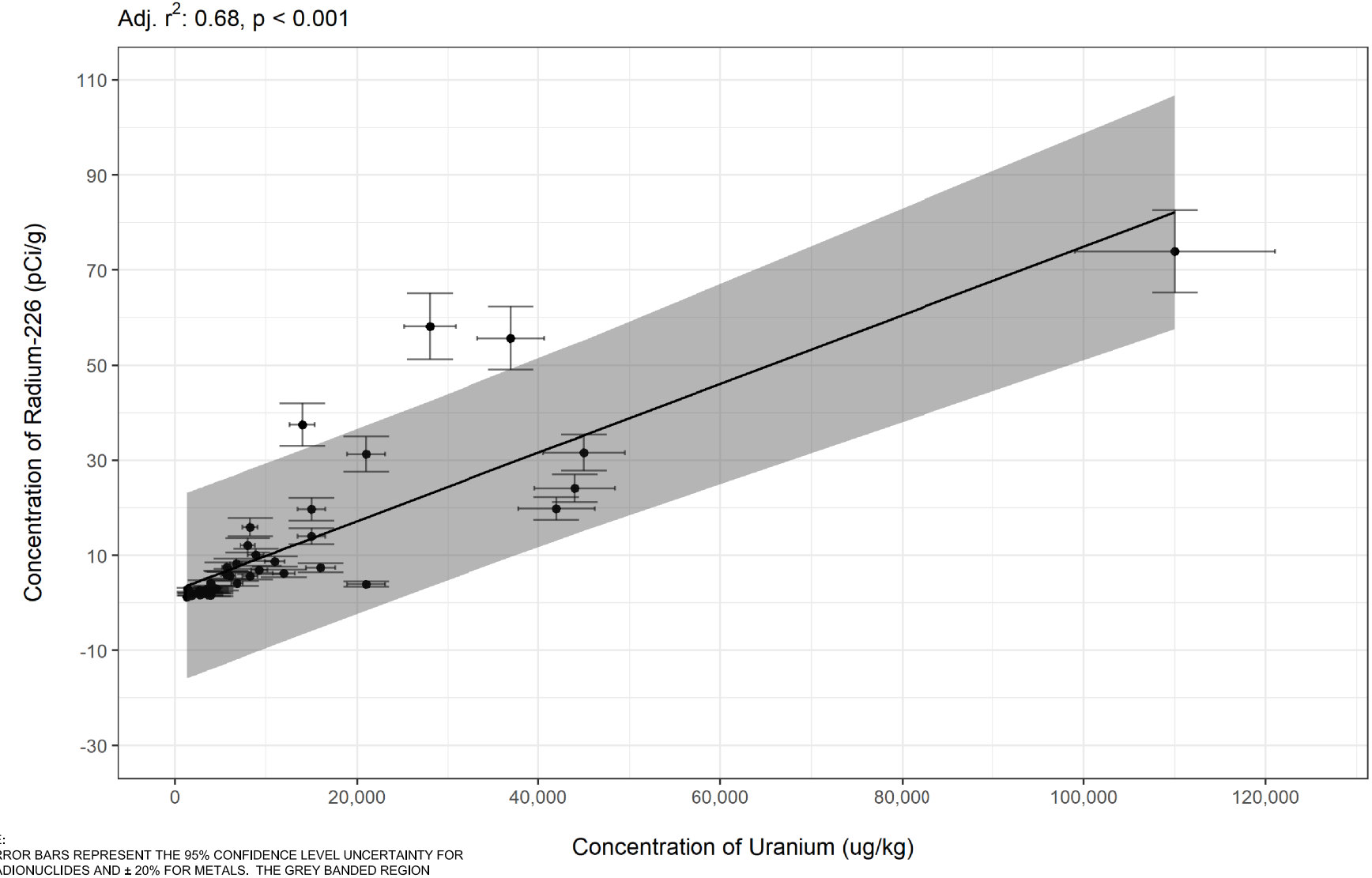
FIGURE 5-10
CORRELATION BETWEEN RADIUM-226 AND SELENIUM
BABBITT RANCHES



NOTE:
1) ERROR BARS REPRESENT THE 95% CONFIDENCE LEVEL UNCERTAINTY FOR RADIONUCLIDES AND ± 20% FOR METALS. THE GREY BANDED REGION REPRESENTS THE 95% PREDICTION INTERVAL OF THE REGRESSION MODEL.

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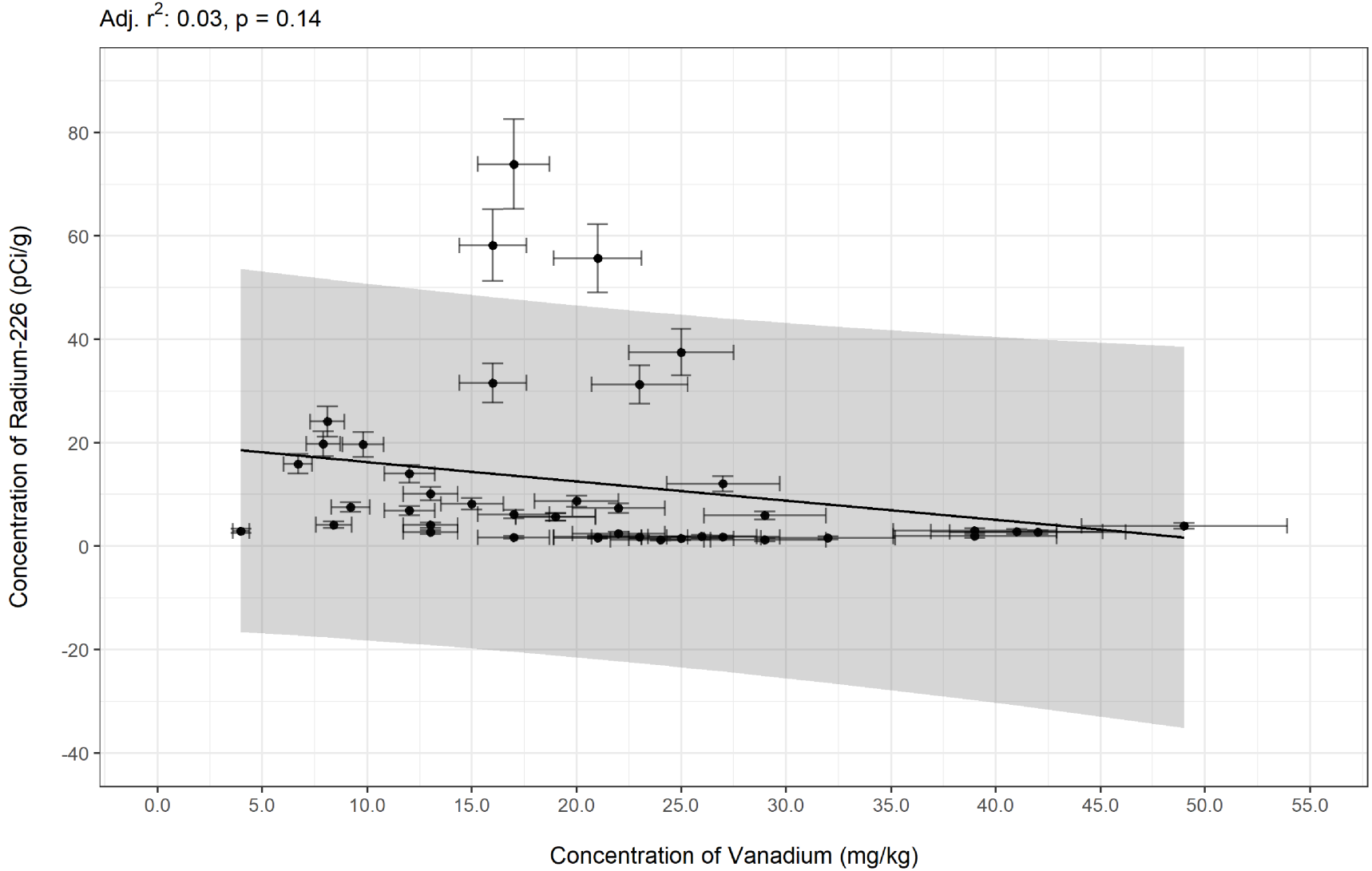
FIGURE 5-11
CORRELATION BETWEEN RADIUM-226 AND URANIUM
BABBITT RANCHES



NOTE:
1) ERROR BARS REPRESENT THE 95% CONFIDENCE LEVEL UNCERTAINTY FOR RADIONUCLIDES AND ± 20% FOR METALS. THE GREY BANDED REGION REPRESENTS THE 95% PREDICTION INTERVAL OF THE REGRESSION MODEL.

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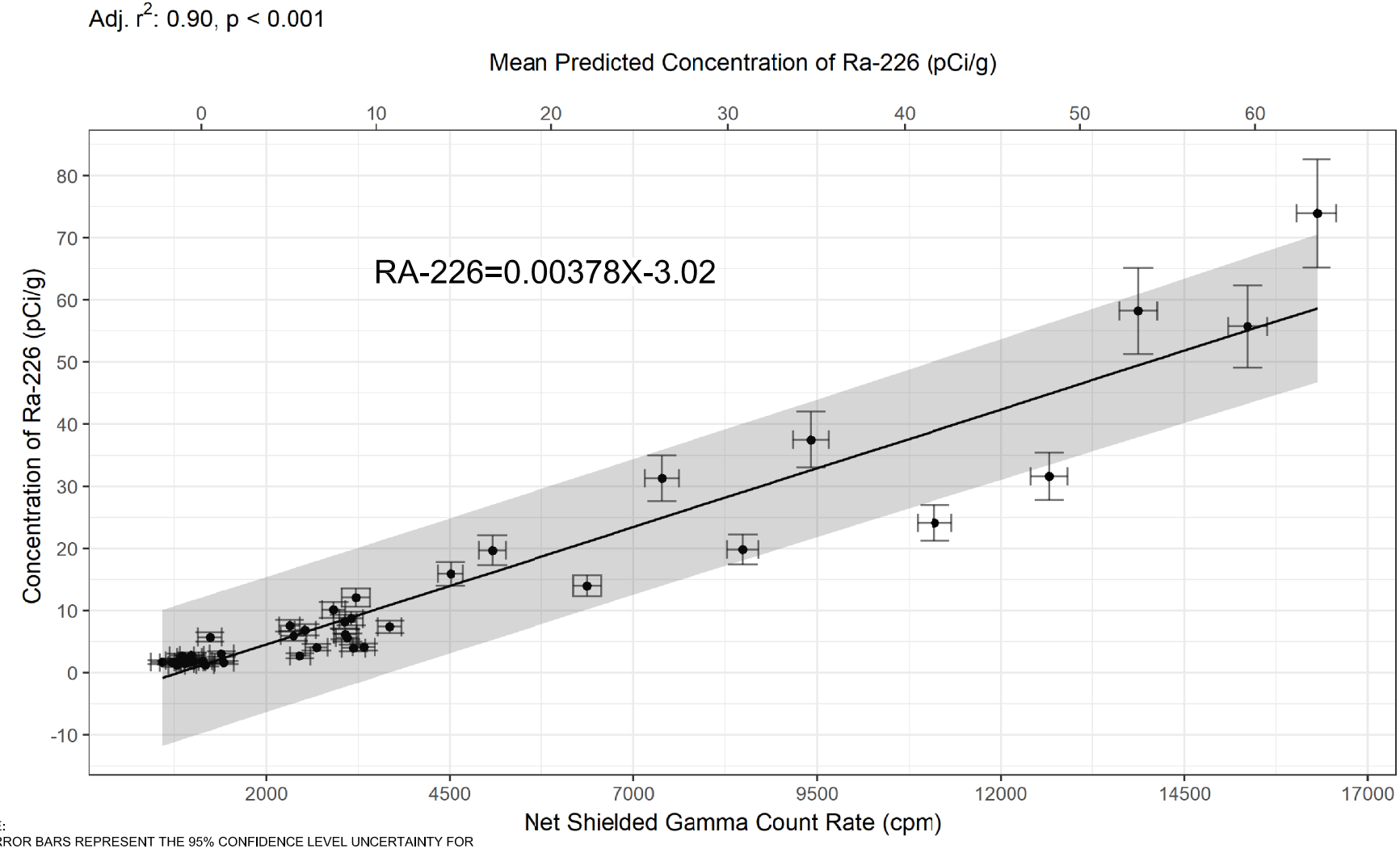
FIGURE 5-12
CORRELATION BETWEEN RADIUM-226 AND VANADIUM
BABBITT RANCHES



NOTE:
1) ERROR BARS REPRESENT THE 95% CONFIDENCE LEVEL UNCERTAINTY FOR RADIONUCLIDES AND ± 20% FOR METALS. THE GREY BANDED REGION REPRESENTS THE 95% PREDICTION INTERVAL OF THE REGRESSION MODEL.
2) A 2-INCH BY 2-INCH NaI DETECTOR WAS USED TO COLLECT GAMMA DATA.

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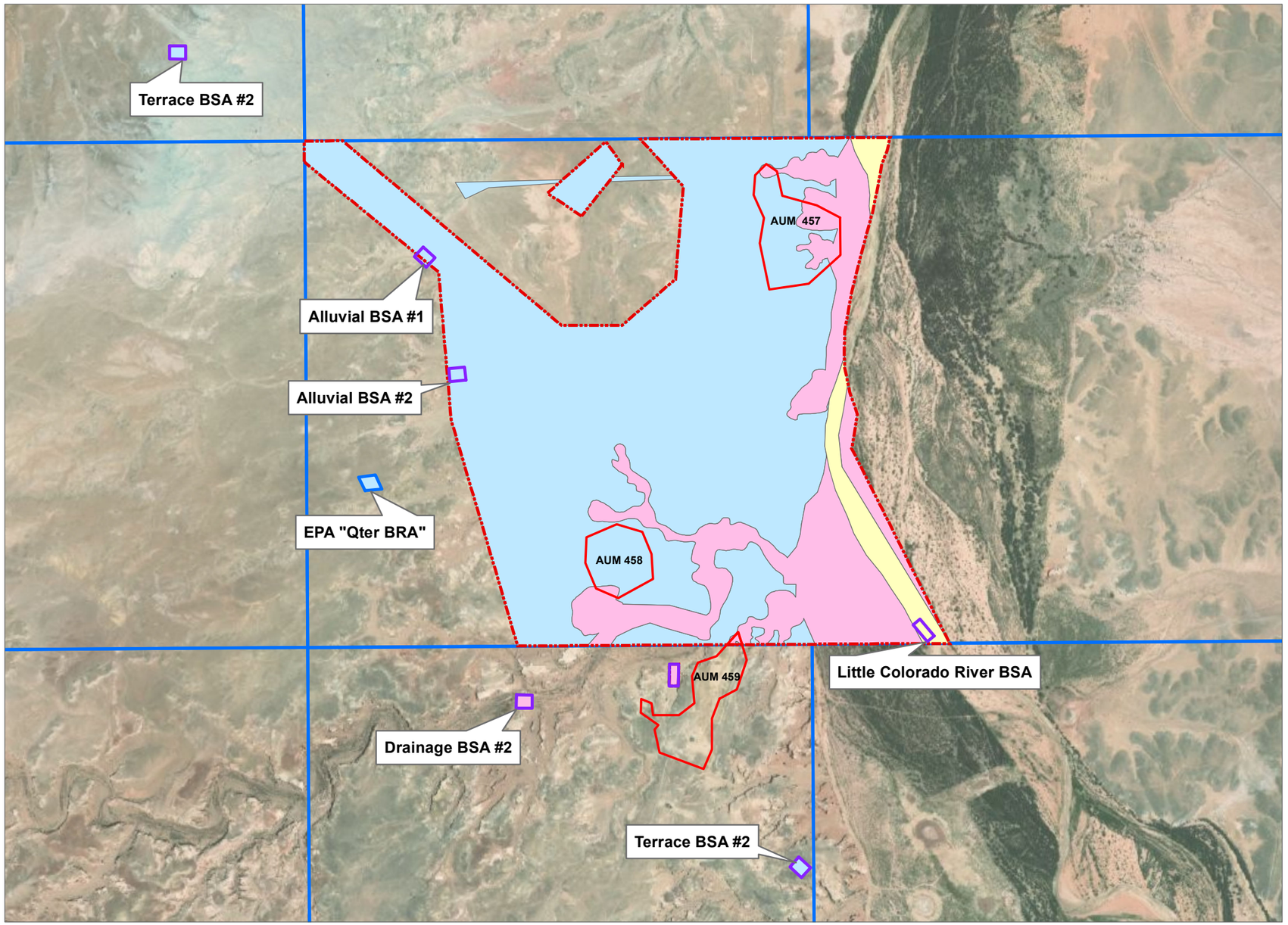
FIGURE 5-13
CORRELATION BETWEEN RADIUM-226 AND GAMMA COUNT RATE WITH OUTLIERS REMOVED
BABBITT RANCHES



LEGEND

- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- EPA AUM Boundary
- LCR Criteria
- Drainage Pooled Criteria
- Alluvial Pooled Criteria
- Section Lines

N

0 600 1,200 2,400

Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 5-14 BSA Application Areas.mxd Date Saved: March, 17, 2021

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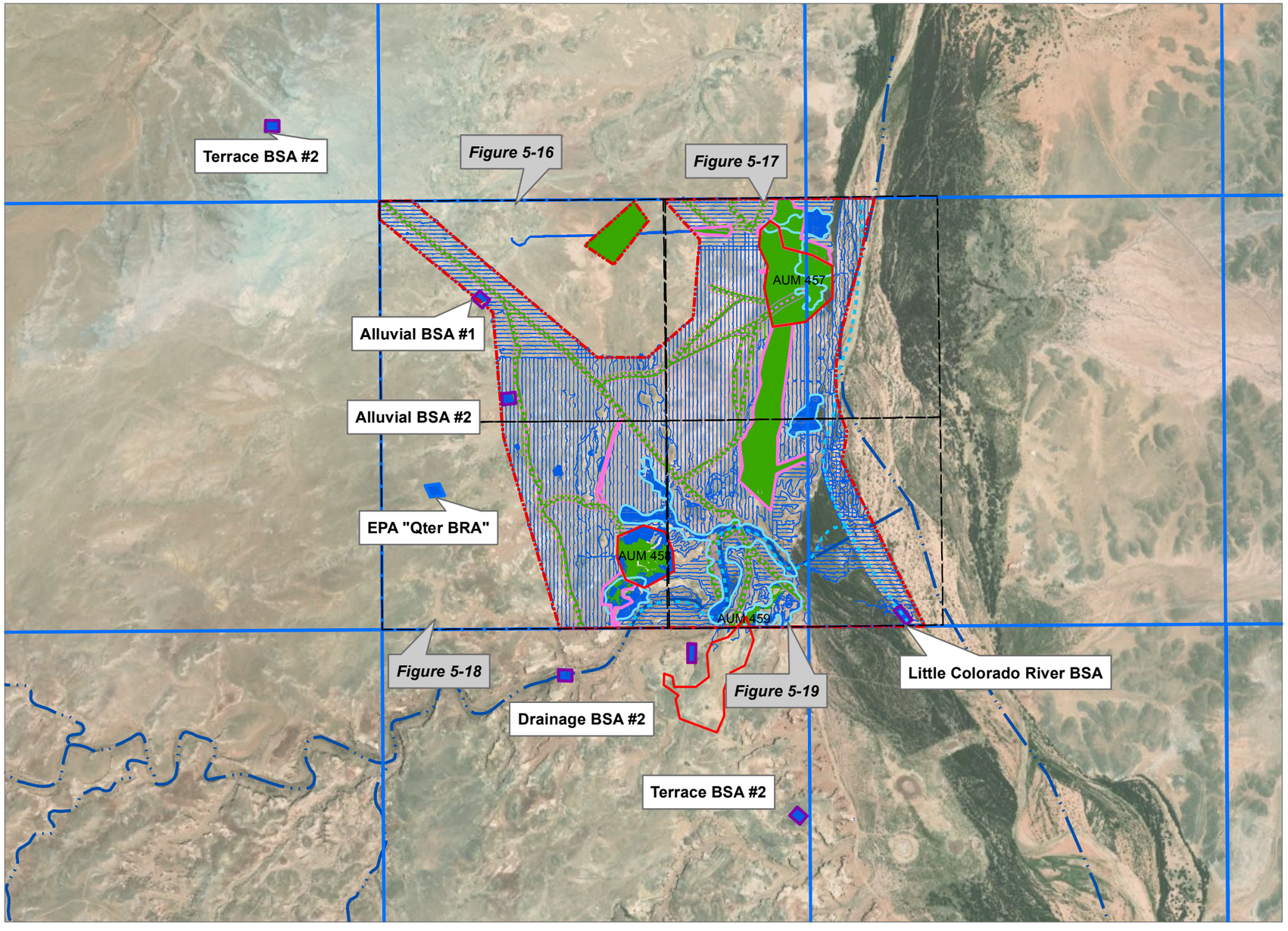
FIGURE 5-14
LOCATION OF BSA APPLICATION AREAS
BABBITT RANCHES



LEGEND

Category

- NORM
- TENORM
- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- Other Mine Related Disturbance
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- EPA Identified Road Buffer (50-ft)
- EPA Idenfied Road Centerline
- 2019 Little Colorado River (NHD)

N

0 700 1,400 2,800

Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 5-15 Tenorm v Norm.mxd Date Saved: March, 17, 2021

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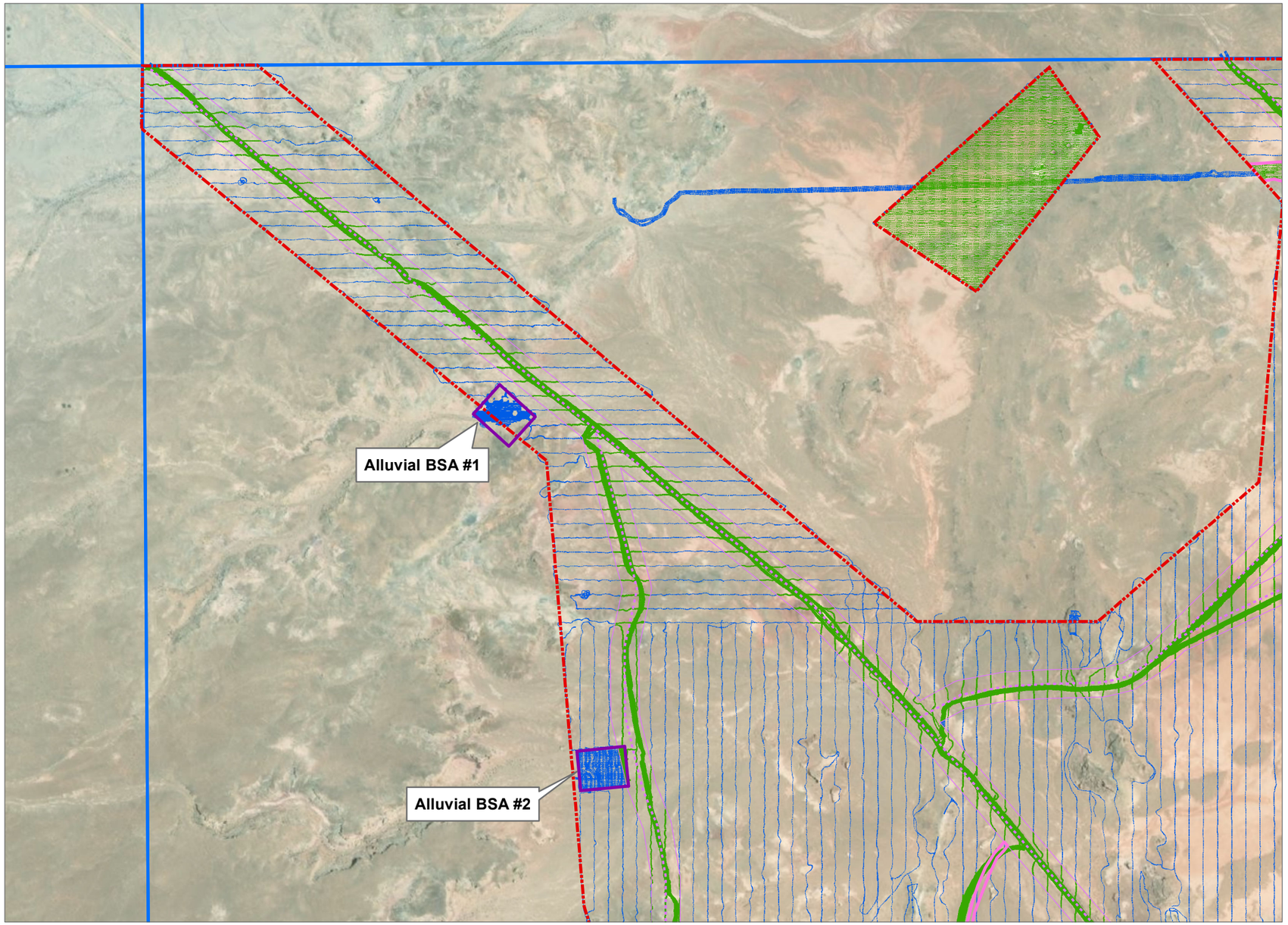
FIGURE 5-15
MAP OF TENORM V NORM
BABBITT RANCHES



LEGEND

Category

- NORM
- TENORM
- EPA AUM
- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- Other Mine Related Disturbance
- EPA Identified Drainage Area
- EPA Identified Drainage Network
- EPA Identified Road Buffer (50-ft)
- EPA Idenfied Road Centerline

N

0 200 400 800

Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mxd\Fig 5-16 Tenorm v Norm NW Quad.mxd Date Saved: March. 17, 2021

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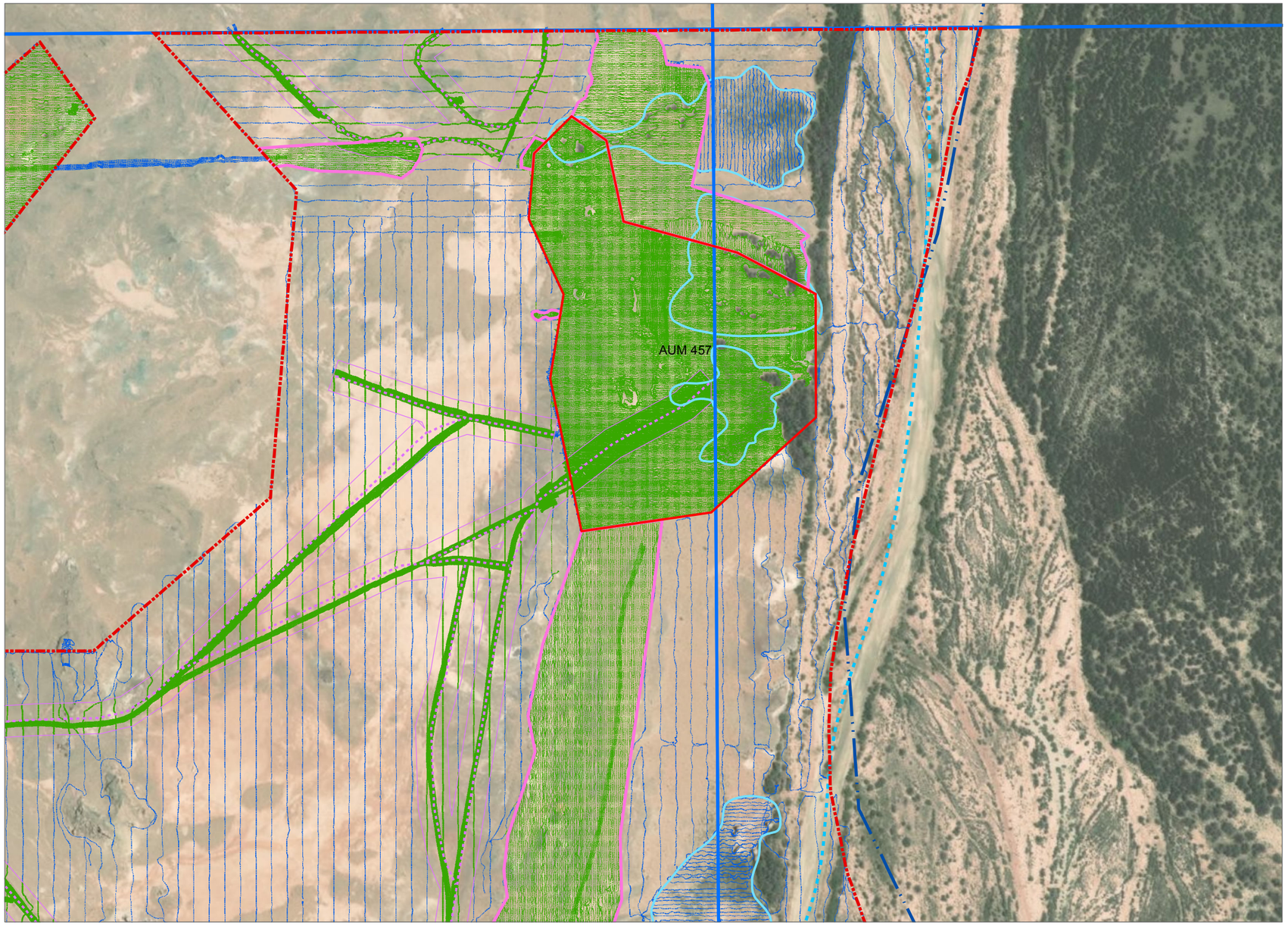
FIGURE 5-16
MAP OF TENORM V NORM FOR NW QUADRANT
BABBITT RANCHES



LEGEND

- EPA AUM Boundary
- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- Other Mine Related Disturbance
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- EPA Identified Road Buffer (50-ft)
- EPA Idenfied Road Centerline
- 2019 Little Colorado River (NHD)

Category

- NORM
- TENORM

0 180 360 720 Feet

NOTE: FOR INFORMATIONAL PURPOSES ONLY. NOT FOR FIELD IMPLEMENTATION.

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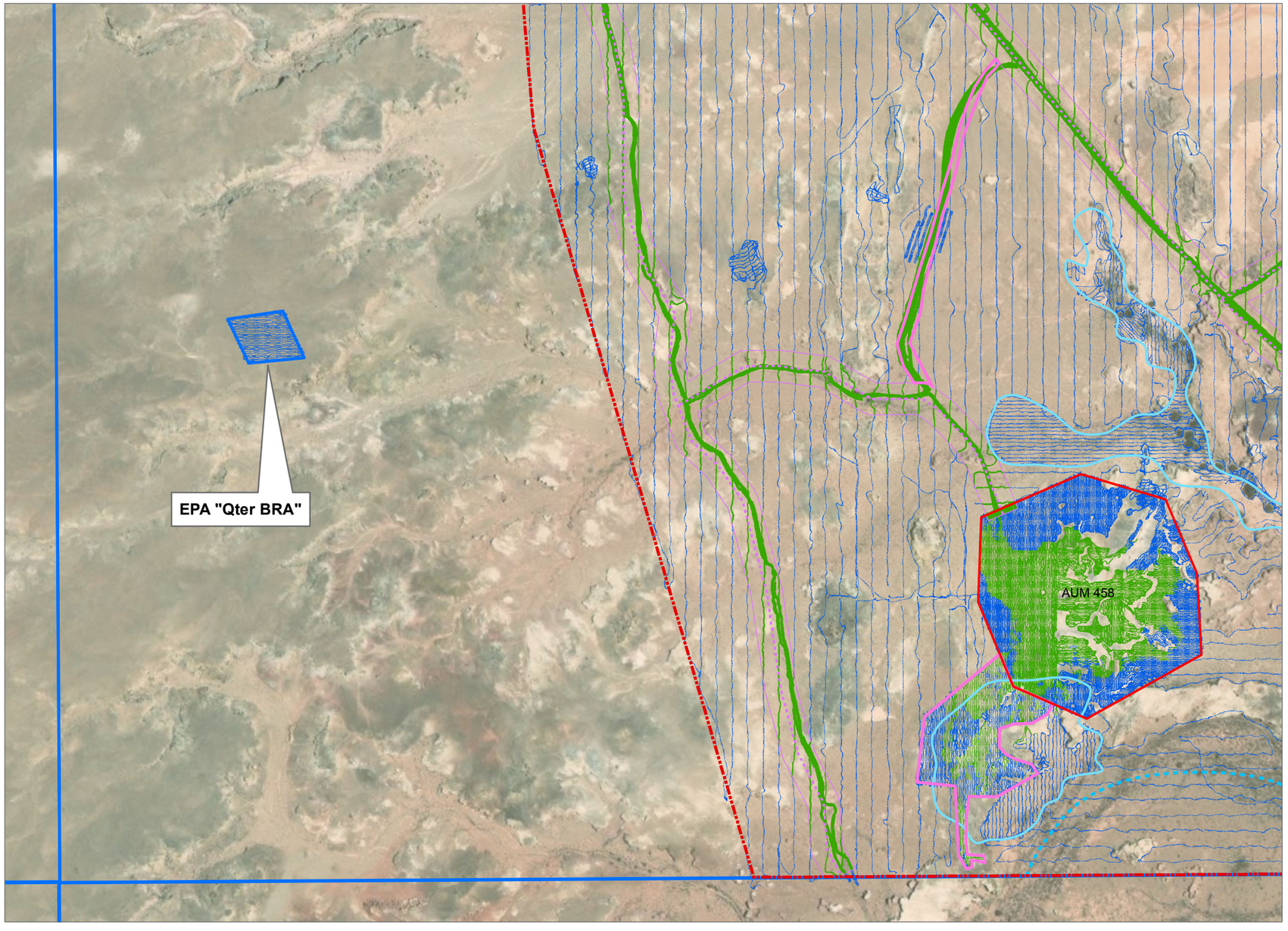
FIGURE 5-17
MAP OF TENORM V NORM FOR NE QUADRANT
BABBITT RANCHES



LEGEND

Category

- NORM
- TENORM
- EPA AUM Boundary
- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- Other Mine Related Disturbance
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- EPA Identified Road Buffer (50-ft)
- EPA Idenfied Road Centerline

N

0 180 360 720

Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1-2 2021 Mxd\Fig 5-18 Tenorm v Norm SW Quad.mxd Date Saved: March 18, 2021

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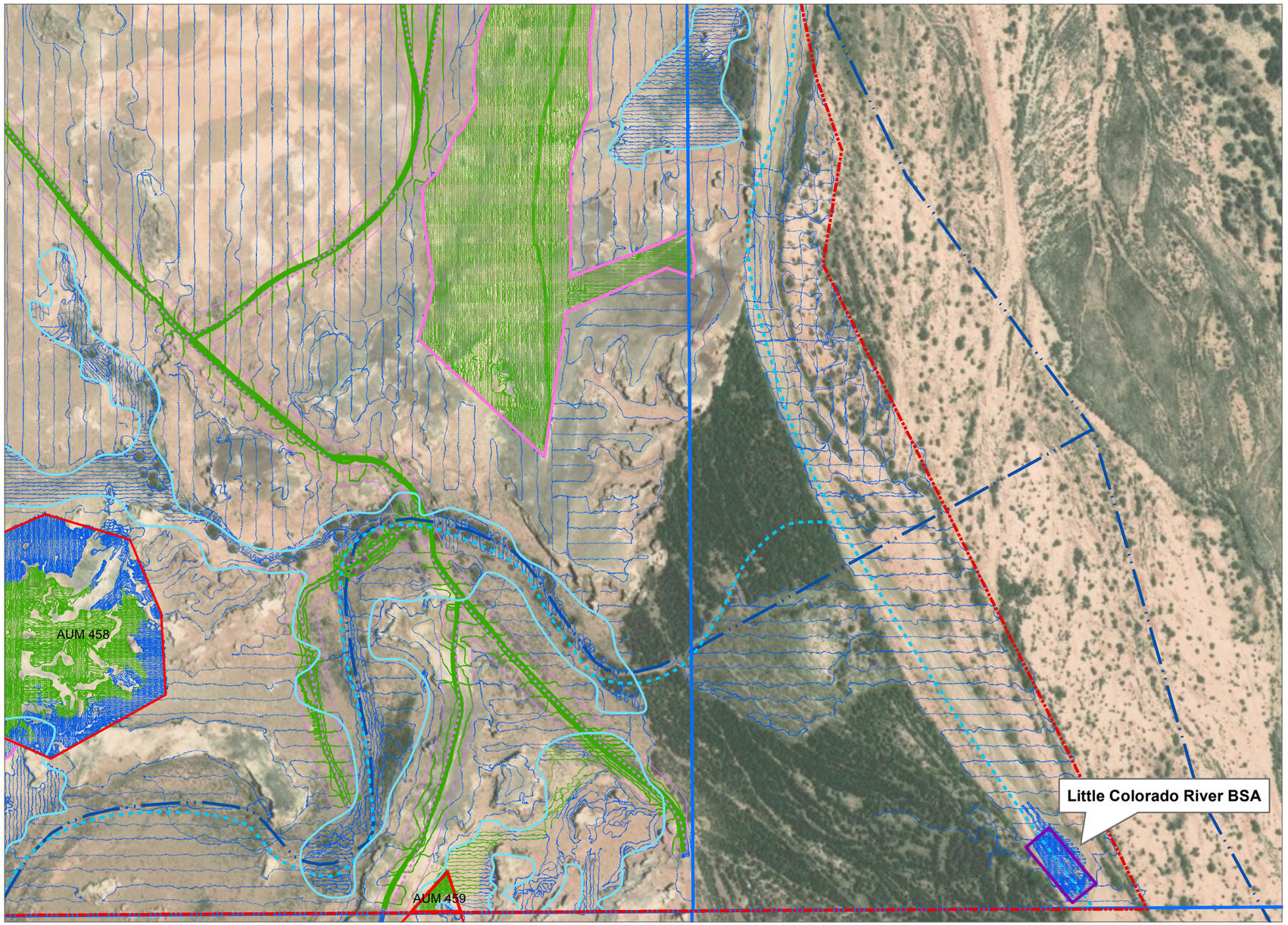
FIGURE 5-18
MAP OF TENORM V NORM FOR SW QUADRANT
BABBITT RANCHES



LEGEND

Category

- NORM
- TENORM
- EPA AUM Boundary
- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- Other Mine Related Disturbance
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- 2019 Little Colorado River (NHD)
- EPA Identified Road Buffer (50-ft)
- EPA Idenfied Road Centerline

N

0 180 360 720

Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mxd\Fig 5-19 Tenorm v Norm SE Quad.mxd Date Saved: February, 05, 2021

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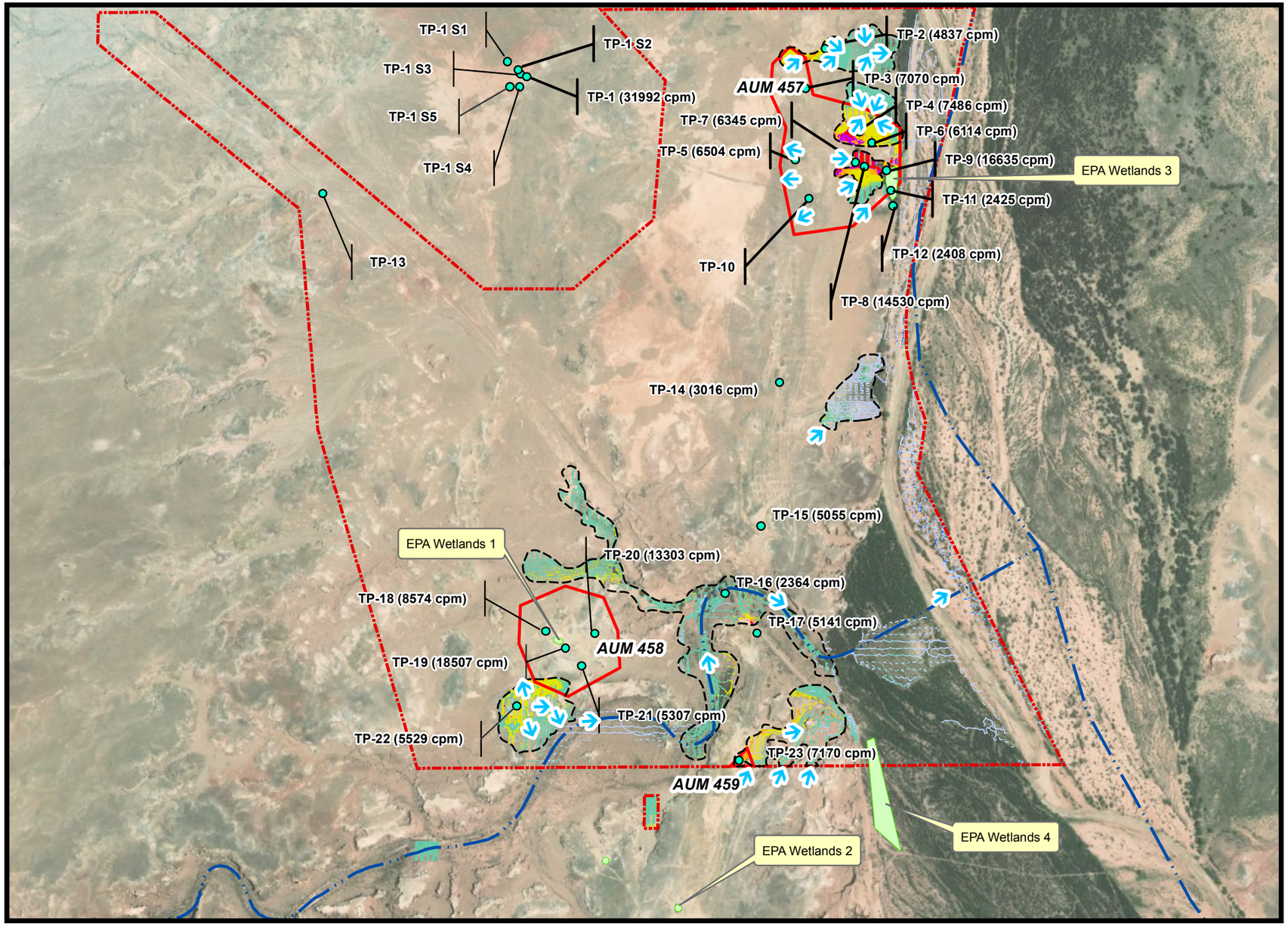
FIGURE 5-19
MAP OF TENORM V NORM FOR SE QUADRANT
BABBITT RANCHES



LEGEND

- Phase III Test Pit Actual Locations With Max Gamma Results
- 2019 Little Colorado River (NHD)
- **Area of Potential Effect**
- EPA Identified Wetlands
- EPA AUM Boundary
- EPA Identified Drainage Area Boundary

Gamma Results Legend

Gamma Scan Results (CPM)

- 21,028 - 23,588
- 23,589 - 35,383
- 35,384 - 47,176
- 47,177 - 70,764
- 70,765 - 94,352
- 94,353 - 141,528
- 141,529 - 646,741
- Surface Water General Flow Direction

NOTES:
1) Gamma Data Obtained from ERG.
2) The Drainage Pooled Criteria shown on Figure 5-14 were used as the boundary for showing the drainage gamma results.
3) The legend shows the minimum (21,028) and maximum (646,741) readings obtained for the drainage areas.
4) IL Values are provided on Table 5-22.

Pooled BSA	95% Gamma UTL (cpm)	IL (cpm)
Alluvial BSA #1 and # 2, Terrace BSA #1 and #2, EPA "Qter BRA"	48,212	51,824
Drainage BSA # 2	43,564	47,176
Little Colorado River BSA	26,053	29,665

5) The IL Application Areas are shown on Figure 5-14.
6) Test Pit Gamma Readings are the maximum gross reading encountered in the test pit (December 2018).
7) Test Pit Gamma Scans were completed using a 2-inch x 2-inch NaI detector.
8) Gamma Scan Results were completed using a 3-inch x 3-inch NaI detector.

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 5-20 Gamma Drainage Areas.mxd Date Saved: March, 17, 2021

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0 400 800 1,600 Feet

FIGURE 5-20
GAMMA CONCENTRATIONS IN DRAINAGE AREAS
BABBITT RANCHES

T: \110704 Babbitt Ranch\Lidar Data 457.dwg SAVED: 3/17/21 PRINTED: 3/17/21

LEGEND:

- 100-YR FLOODPLAIN
- APPROX. EXTENT OF PIT BOUNDARY
- EXISTING CONTOURS (LiDAR, MASER, 2016)
- AUM BOUNDARY
- VALLEY CHANNEL
- EXISTING ROAD

NORTH

APPROXIMATE SCALE IN FEET

0 100'

APPROX. EXTENT OF PIT BOUNDARY

AUM BOUNDARY

AUM 457

100-YR FLOODPLAIN BOUNDARY

Project No. 110704

100-YEAR FLOODPLAIN BOUNDARY
EXPORTED FROM FEMA MAPPING
ON 8/27/2019.

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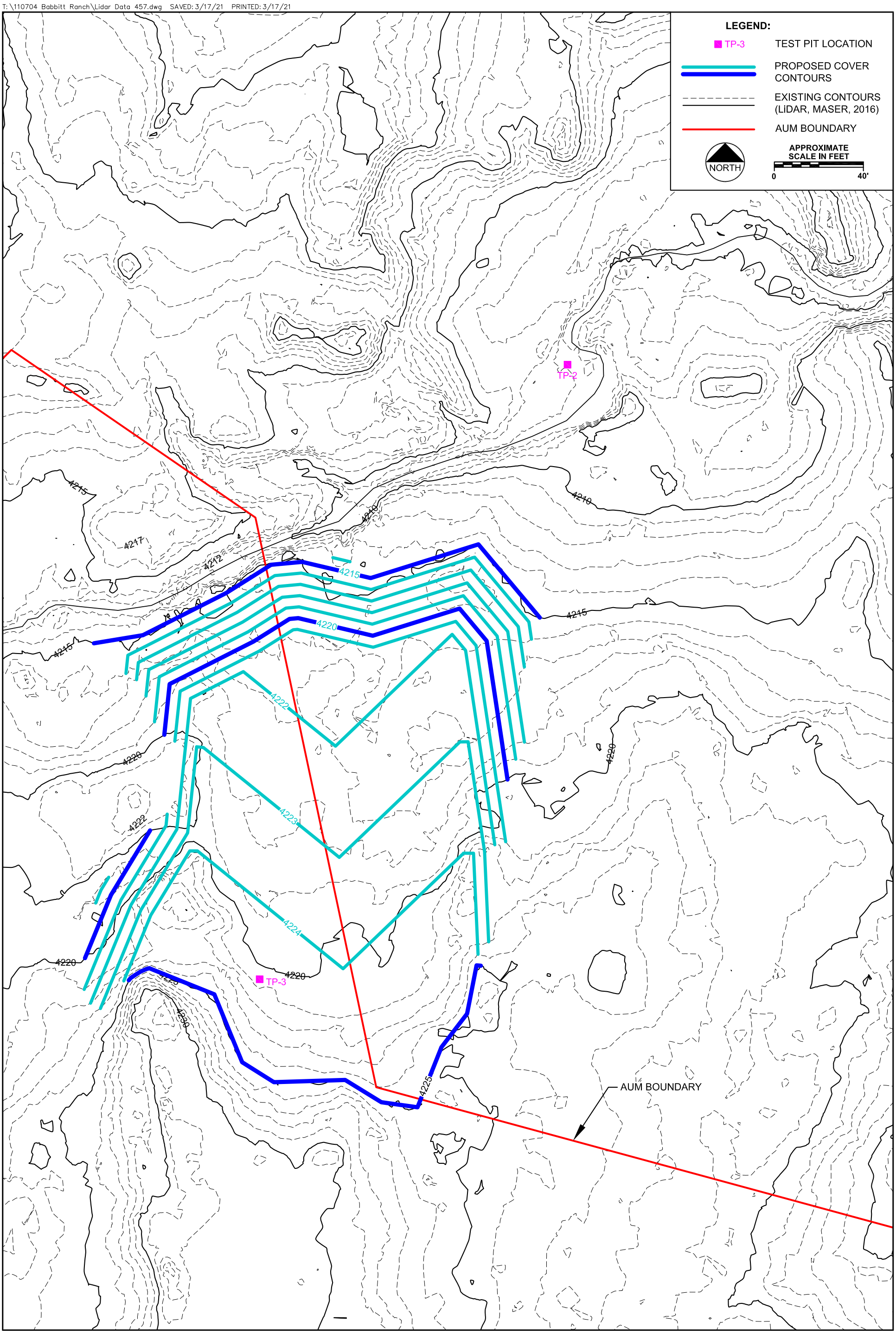
FIGURE 9-1
AUM 457 LiDAR DATA (MASER, 2016)
BABBITT RANCHES

T:\110704 Babbitt Ranch\Lidar Data 457.dwg SAVED: 3/17/21 PRINTED: 3/17/21



Project No. 110704

Pit Volume: 1340 Cu Yd
3' Cover Above Pit: 3130 Cu Yd
Total Volume: 4470 Cu Yd

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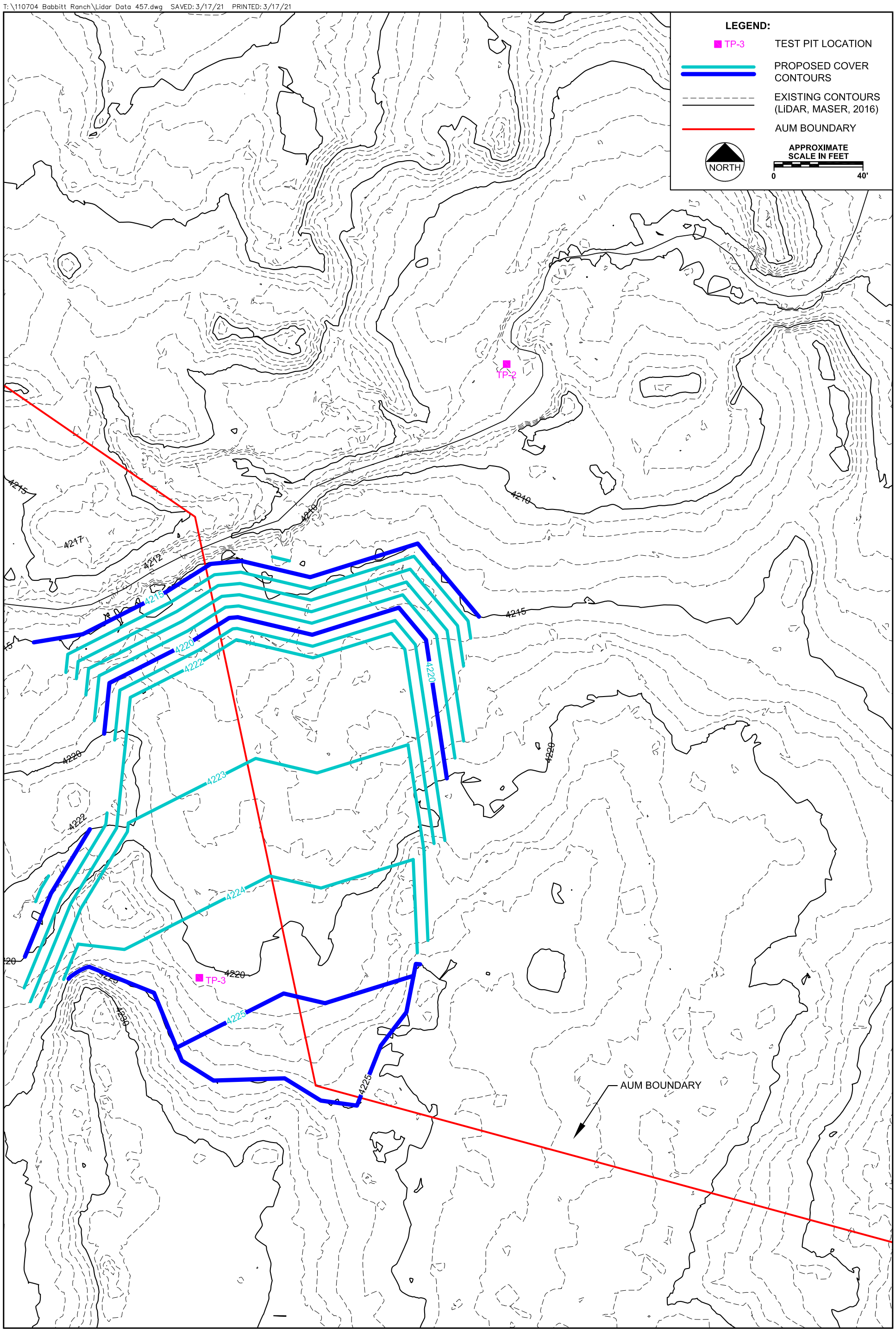
FIGURE 9-2
AUM 457 CONCEPTUAL REPOSITORY DESIGN
CHANNEL COVER SURFACE
BABBITT RANCHES

T:\110704 Babbitt Ranch\Lidar Data 457.dwg SAVED: 3/17/21 PRINTED: 3/17/21



Project No. 110704

Pit Volume: 1560 Cu Yd
3' Cover Above Pit: 3070 Cu Yd
Total Volume: 4630 Cu Yd

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FIGURE 9-3
AUM 457 CONCEPTUAL REPOSITORY DESIGN
MOUND COVER SURFACE
BABBITT RANCHES

T:\110704 Babbitt Ranch\Lidar Data 458.dwg SAVED: 3/17/21 PRINTED: 3/17/21

100-YEAR FLOODPLAIN BOUNDARY
EXPORTED FROM FEMA MAPPING
ON 8/27/2019.

NORTH

APPROXIMATE
SCALE IN FEET
0 100'

LEGEND:

- 100-YR FLOODPLAIN
- APPROX. EXTENT OF PIT BOUNDARY
- EXISTING CONTOURS (LiDAR, MASER, 2016)
- AUM BOUNDARY

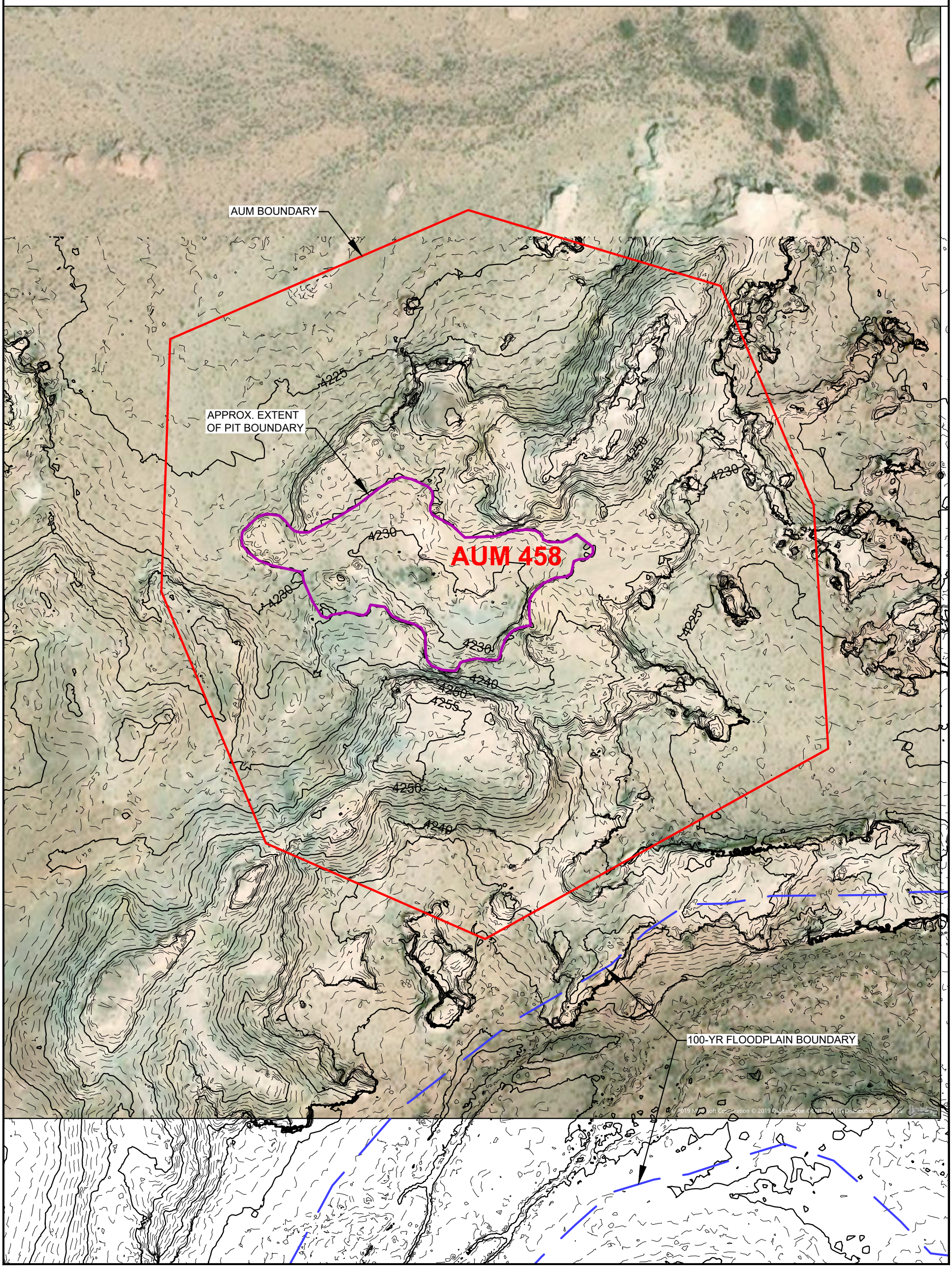

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FIGURE 9-4
AUM 458 LiDAR DATA (MASER, 2016)
BABBITT RANCHES

T:\110704 Babbitt Ranch\Lidar Data 458.dwg SAVED: 3/17/21 PRINTED: 3/17/21

LEGEND:

- TP-3 — TEST PIT LOCATION
- PROPOSED COVER CONTOURS
- EXISTING CONTOURS (LiDAR, MASER, 2016)
- AUM BOUNDARY
- NORTH
- APPROXIMATE SCALE IN FEET: 0 — 40'

4235 4233 4231 4230 4231 4232 4230 4235 4231 4230 4233 4230 4229 4233 4235 4228 4234

AUM BOUNDARY

Project No. 110704

Pit Volume: 740 Cu Yd
3' Cover Above Pit: 2030 Cu Yd
Total Volume: 2770 Cu Yd

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FIGURE 9-5
AUM 458 CONCEPTUAL REPOSITORY DESIGN
CHANNEL COVER SURFACE
BABBITT RANCHES

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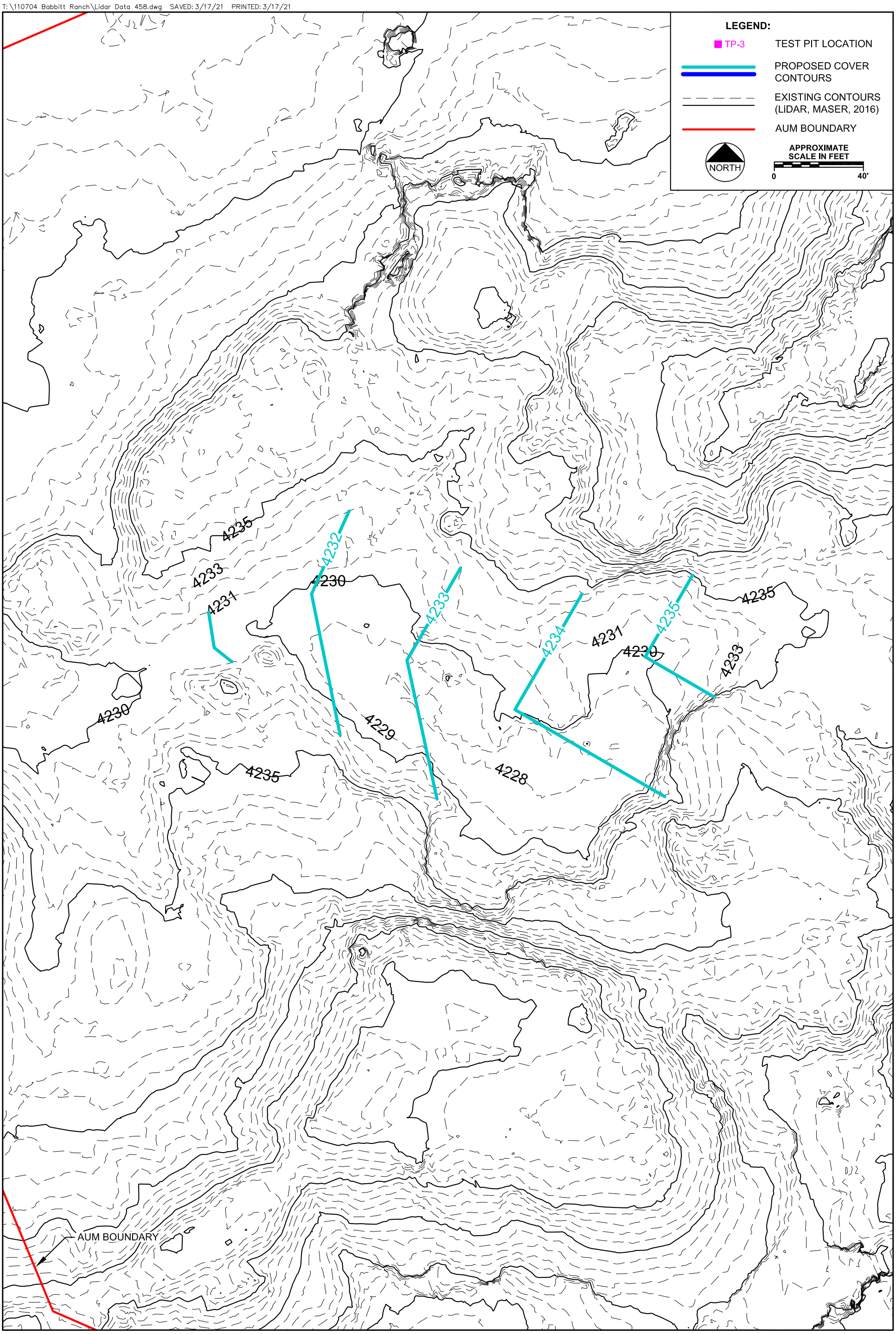

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Pit Volume: 800 Cu Yd
3' Cover Above Pit: 2020 Cu Yd
Total Volume: 2820 Cu Yd

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FIGURE 9-6
AUM 458 CONCEPTUAL REPOSITORY DESIGN
MOUND COVER SURFACE
BABBITT RANCHES

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LEGEND:

PROPOSED COVER CONTOURS

EXISTING CONTOURS (LiDAR, MASER, 2016)

AUM BOUNDARY

NORTH

APPROXIMATE SCALE IN FEET

0 40'

4235 4233 4231 4230 4236 4240 4244 4231 4230 4233 4235 4229 4229 4235

AUM BOUNDARY

Project No. 110704

Waste Volume: 5670 Cu Yd
3' Cover Above Waste: 3700 Cu Yd
Total Volume: 9370 Cu Yd

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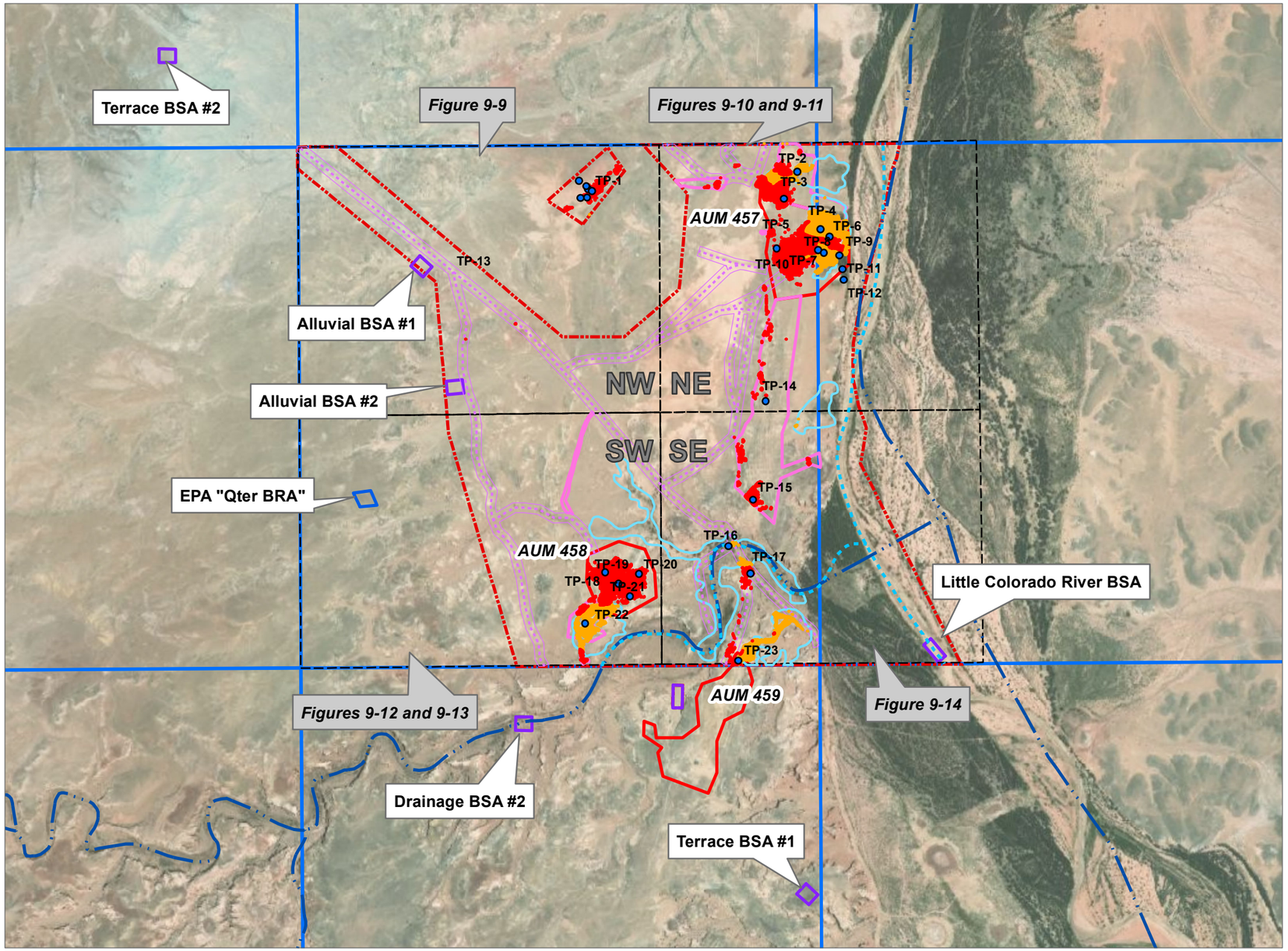
FIGURE 9-7
AUM 458 CONCEPTUAL REPOSITORY DESIGN
RAISED MOUND COVER SURFACE
BABBITT RANCHES



LEGEND

- Phase III Test Pits
- Alluvial TENORM Gamma Result above IL
- Drainage TENORM Gamma Result above IL
- EPA Identified Drainage Network
- 2019 Little Colorado River (NHD)
- EPA Identified Road Centerline
- EPA Identified Drainage Area Boundary
- EPA Identified Road Buffer (50-ft)
- Other Mine Related Disturbance (1)
- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary

NOTES:
1) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).
2) The IL Application Areas are shown on Figure 5-14.
3) IL Values are as follows:

TABLE A: HORIZONTAL CORRELATION

Pool	Background pCi/g	IL pCi/g	gamma - mean cpm
Drainage	1.71	2.95	48419
Alluvial	3.72	4.96	67169
LCR	1.26	2.5	44221

TABLE B: VERTICAL CORRELATION

Pool	Background pCi/g	IL pCi/g	NET gamma - mean cpm
Drainage	1.71	2.95	1828
Alluvial	3.72	4.96	2307
LCR	1.26	2.5	1721

4) Total Removal Volume for IL in the four quadrants is 31,500 cubic yards.

N

0 625 1,250 2,500 Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 9-8 Gamma Scan Results w TP.mxd Date Saved: March 18, 2021

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FIGURE 9-8
RESULTS OF MOBILE GAMMA SCAN SURVEY ABOVE IL WITH TEST PIT LOCATIONS
BABBITT RANCHES

TP-1	(ALLUVIAL)	
Depth	Net Gamma	Exceeds IL (2295)
0-0.5'	6,122	YES
0.5'-1.0'	12,658	YES
1.0'-1.5'	16,230	YES
1.5'-2.0'	30,360	YES
2.0'-2.5'	6,764	YES
2.5'-3.0'	3,185	YES
3.0'-3.5'	N/A	N/A

3'

3'

3'

3'

Alluvial BSA #1

Alluvial BSA #2

LEGEND

- Phase III Test Pits
- Alluvial TENORM Gamma Result above IL
- Depth of TENORM above IL Contours
- Babbitt BSA Locations
- Area of Potential Effect
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline

NOTES:
1) The IL Application Areas are shown on Figure 5-14.
2) IL Values are as follows:

TABLE A: HORIZONTAL CORRELATION			
Pool	Background pCi/g	IL pCi/g	gamma - mean cpm
Drainage	1.71	2.95	48419
Alluvial	3.72	4.96	67169
LCR	1.26	2.5	44221

TABLE B: VERTICAL CORRELATION			
Pool	Background pCi/g	IL pCi/g	NET gamma - mean cpm
Drainage	1.71	2.95	1828
Alluvial	3.72	4.96	2307
LCR	1.26	2.5	1721

3) Total volume of TENORM above IL in this Quadrant: 4087 Cu. Yd.
4) Not all 1" contours are shown.

N

0 150 300 600 Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 9-9 Gamma Scan Results - NW w TP.mxd Date Saved: March, 18, 2021

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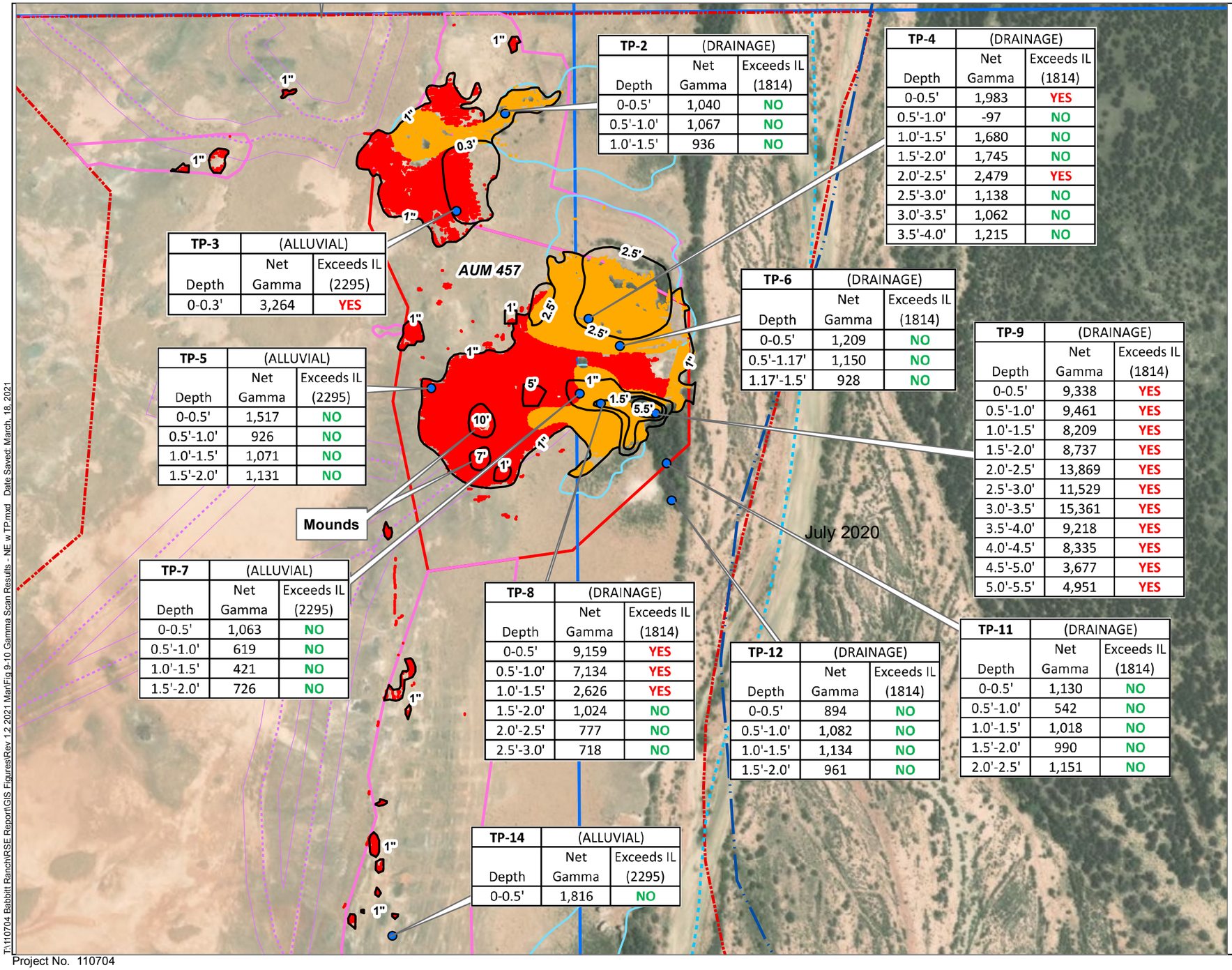
FIGURE 9-9
RESULTS OF MOBILE GAMMA SCAN SURVEY ABOVE IL WITH TEST PIT LOCATIONS
NW QUADRANT
BABBITT RANCHES



TP-2	(DRAINAGE)	
Depth	Net Gamma	Exceeds IL (1814)
0-0.5'	1,040	NO
0.5'-1.0'	1,067	NO
1.0'-1.5'	936	NO

TP-3	(ALLUVIAL)	
Depth	Net Gamma	Exceeds IL (2295)
0-0.3'	3,264	YES

TP-4	(DRAINAGE)	
Depth	Net Gamma	Exceeds IL (1814)
0-0.5'	1,983	YES
0.5'-1.0'	-97	NO
1.0'-1.5'	1,680	NO
1.5'-2.0'	1,745	NO
2.0'-2.5'	2,479	YES
2.5'-3.0'	1,138	NO
3.0'-3.5'	1,062	NO
3.5'-4.0'	1,215	NO

TP-5	(ALLUVIAL)	
Depth	Net Gamma	Exceeds IL (2295)
0-0.5'	1,517	NO
0.5'-1.0'	926	NO
1.0'-1.5'	1,071	NO
1.5'-2.0'	1,131	NO

TP-6	(DRAINAGE)	
Depth	Net Gamma	Exceeds IL (1814)
0-0.5'	1,209	NO
0.5'-1.17'	1,150	NO
1.17'-1.5'	928	NO

TP-9	(DRAINAGE)	
Depth	Net Gamma	Exceeds IL (1814)
0-0.5'	9,338	YES
0.5'-1.0'	9,461	YES
1.0'-1.5'	8,209	YES
1.5'-2.0'	8,737	YES
2.0'-2.5'	13,869	YES
2.5'-3.0'	11,529	YES
3.0'-3.5'	15,361	YES
3.5'-4.0'	9,218	YES
4.0'-4.5'	8,335	YES
4.5'-5.0'	3,677	YES
5.0'-5.5'	4,951	YES

TP-7	(ALLUVIAL)	
Depth	Net Gamma	Exceeds IL (2295)
0-0.5'	1,063	NO
0.5'-1.0'	619	NO
1.0'-1.5'	421	NO
1.5'-2.0'	726	NO

TP-8	(DRAINAGE)	
Depth	Net Gamma	Exceeds IL (1814)
0-0.5'	9,159	YES
0.5'-1.0'	7,134	YES
1.0'-1.5'	2,626	YES
1.5'-2.0'	1,024	NO
2.0'-2.5'	777	NO
2.5'-3.0'	718	NO

TP-12	(DRAINAGE)	
Depth	Net Gamma	Exceeds IL (1814)
0-0.5'	894	NO
0.5'-1.0'	1,082	NO
1.0'-1.5'	1,134	NO
1.5'-2.0'	961	NO

TP-11	(DRAINAGE)	
Depth	Net Gamma	Exceeds IL (1814)
0-0.5'	1,130	NO
0.5'-1.0'	542	NO
1.0'-1.5'	1,018	NO
1.5'-2.0'	990	NO
2.0'-2.5'	1,151	NO

TP-14	(ALLUVIAL)	
Depth	Net Gamma	Exceeds IL (2295)
0-0.5'	1,816	NO

LEGEND

- Phase III Test Pits
- EPA Identified Drainage Network
- 2019 Little Colorado River (NHD)
- Depth of TENORM above IL Contours
- Alluvial TENORM Gamma Result above IL
- Drainage TENORM Gamma Result above IL
- EPA Identified Road Centerline
- EPA Identified Drainage Area Boundary
- EPA Identified Road Buffer (50-ft)
- Other Mine Related Disturbance (1)
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary

NOTES:
1) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).
2) The IL Application Areas are shown on Figure 5-14.
3) IL Values are as follows:

TABLE A: HORIZONTAL CORRELATION			
Pool	Background pCi/g	IL pCi/g	gamma - mean cpm
Drainage	1.71	2.95	48419
Alluvial	3.72	4.96	67169
LCR	1.26	2.5	44221

TABLE B: VERTICAL CORRELATION			
Pool	Background pCi/g	IL pCi/g	NET gamma - mean cpm
Drainage	1.71	2.95	1828
Alluvial	3.72	4.96	2307
LCR	1.26	2.5	1721

4) Volume estimates for this quadrant are shown on Figure 9-11.
5) Not all 1" contours are shown.

N

0 150 300 600 Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 9-10 Gamma Scan Results - NE w TP.mxd Date Saved: March, 18, 2021

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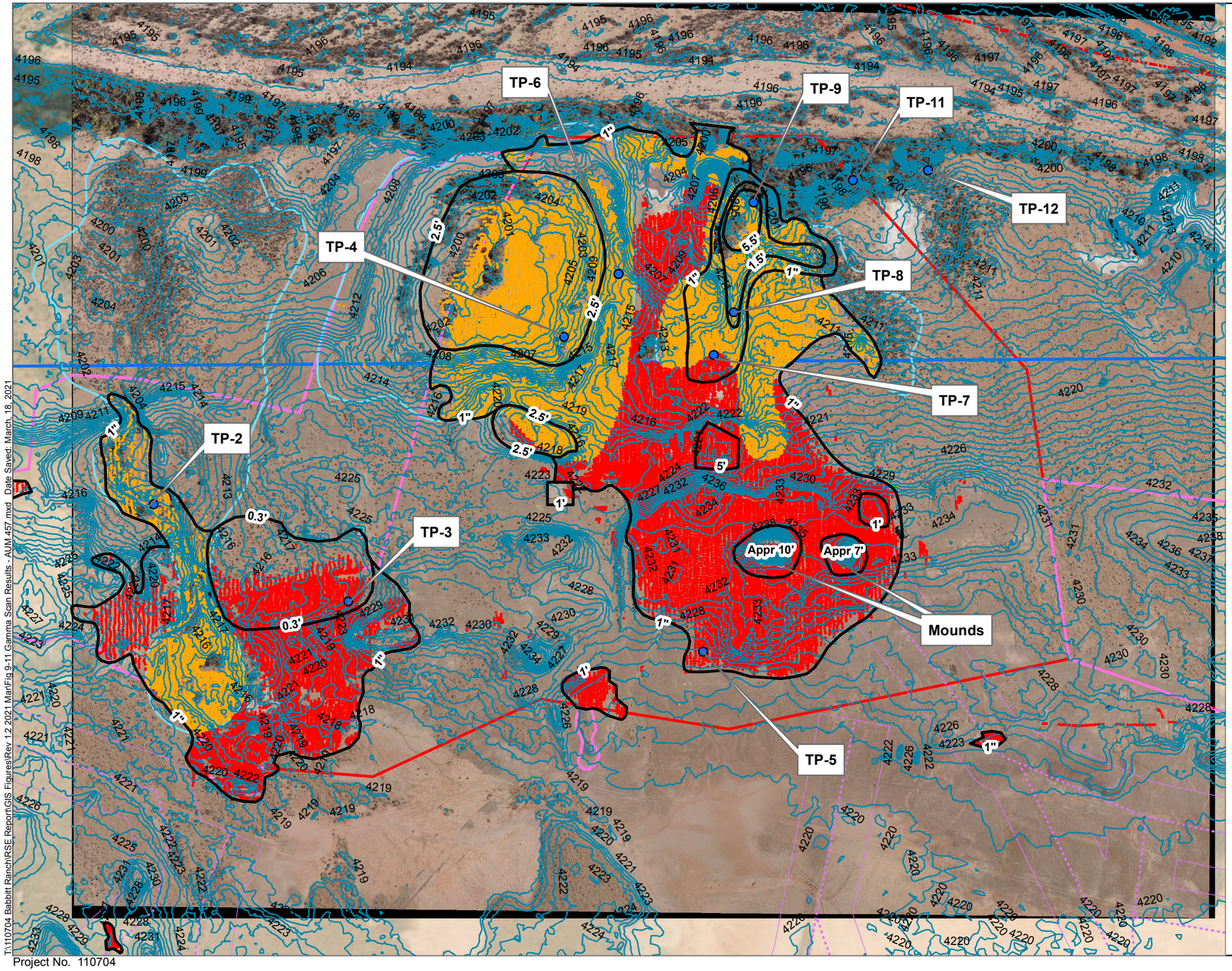
FIGURE 9-10
RESULTS OF MOBILE GAMMA SCAN SURVEY ABOVE IL WITH TEST PIT LOCATIONS
NE QUADRANT
BABBITT RANCHES



LEGEND

- Phase III Test Pits
- Alluvial TENORM Gamma Result above IL
- Drainage TENORM Gamma Result above IL
- Existing Contours (Maser, 2016)
- Depth of TENORM above IL Contours
- EPA AUM Boundary
- Area of Potential Effect
- Section Lines
- Other Mine Related Disturbance (1)
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline

NOTES:
1) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).
2) The IL Application Areas are shown on Figure 5-14.
3) IL Values are as follows:

TABLE A: HORIZONTAL CORRELATION

Pool	Background pCi/g	IL pCi/g	gamma - mean cpm
Drainage	1.71	2.95	48419
Alluvial	3.72	4.96	67169
LCR	1.26	2.5	44221

TABLE B: VERTICAL CORRELATION

Pool	Background pCi/g	IL pCi/g	NET gamma - mean cpm
Drainage	1.71	2.95	1828
Alluvial	3.72	4.96	2307
LCR	1.26	2.5	1721

4) Total volume of TENORM above IL in this Quadrant: 10,209 Cu. Yd.
5) Not all 1" contours are shown.

N

0 75 150 300
Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 9-11 Gamma Scan Results - AUM 457.mxd Date Saved: March 18, 2021

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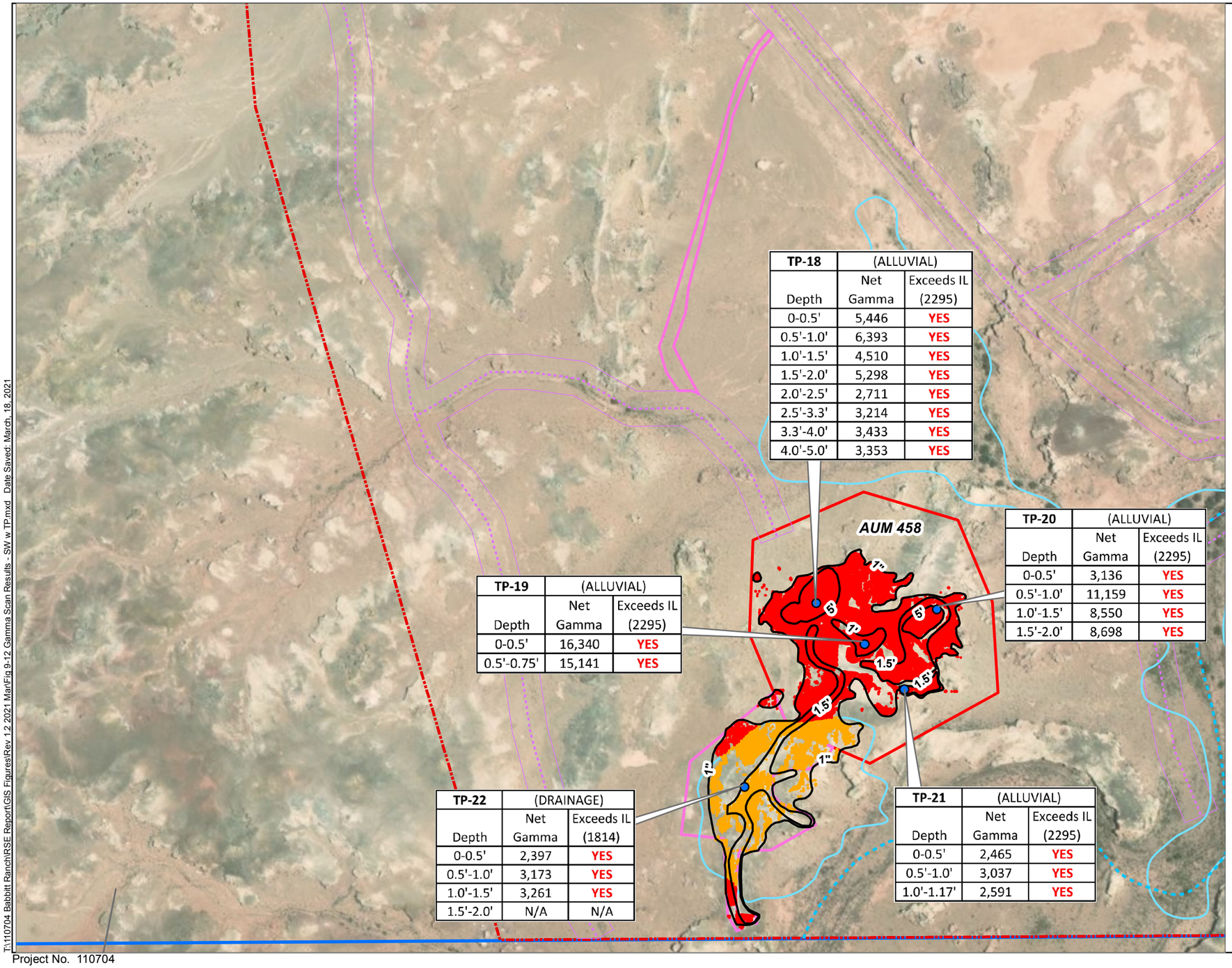
FIGURE 9-11
VOLUME ESTIMATE ABOVE IL AT AUM 457
BABBITT RANCHES



TP-18	(ALLUVIAL)	
Depth	Net Gamma	Exceeds IL (2295)
0-0.5'	5,446	YES
0.5'-1.0'	6,393	YES
1.0'-1.5'	4,510	YES
1.5'-2.0'	5,298	YES
2.0'-2.5'	2,711	YES
2.5'-3.3'	3,214	YES
3.3'-4.0'	3,433	YES
4.0'-5.0'	3,353	YES

TP-19	(ALLUVIAL)	
Depth	Net Gamma	Exceeds IL (2295)
0-0.5'	16,340	YES
0.5'-0.75'	15,141	YES

TP-20	(ALLUVIAL)	
Depth	Net Gamma	Exceeds IL (2295)
0-0.5'	3,136	YES
0.5'-1.0'	11,159	YES
1.0'-1.5'	8,550	YES
1.5'-2.0'	8,698	YES

TP-22	(DRAINAGE)	
Depth	Net Gamma	Exceeds IL (1814)
0-0.5'	2,397	YES
0.5'-1.0'	3,173	YES
1.0'-1.5'	3,261	YES
1.5'-2.0'	N/A	N/A

TP-21	(ALLUVIAL)	
Depth	Net Gamma	Exceeds IL (2295)
0-0.5'	2,465	YES
0.5'-1.0'	3,037	YES
1.0'-1.17'	2,591	YES

LEGEND

- Phase III Test Pits
- Alluvial TENORM Gamma Result above IL
- Drainage TENORM Gamma Result above IL
- Depth of TENORM above IL Contours
- EPA AUM Boundary
- Area of Potential Effect
- Section Lines
- Other Mine Related Disturbance (1)
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline

NOTES:
1) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).
2) The IL Application Areas are shown on Figure 5-14.

TABLE A: HORIZONTAL CORRELATION

Pool	Background pCi/g	IL pCi/g	gamma - mean cpm
Drainage	1.71	2.95	48419
Alluvial	3.72	4.96	67169
LCR	1.26	2.5	44221

TABLE B: VERTICAL CORRELATION

Pool	Background pCi/g	IL pCi/g	NET gamma - mean cpm
Drainage	1.71	2.95	1828
Alluvial	3.72	4.96	2307
LCR	1.26	2.5	1721

4) Volume estimates for this quadrant are shown on Figure 9-13.
5) Not all 1" contours are shown.

0 150 300 600 Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 9-12 Gamma Scan Results - SW w TP.mxd Date Saved: March 18, 2021

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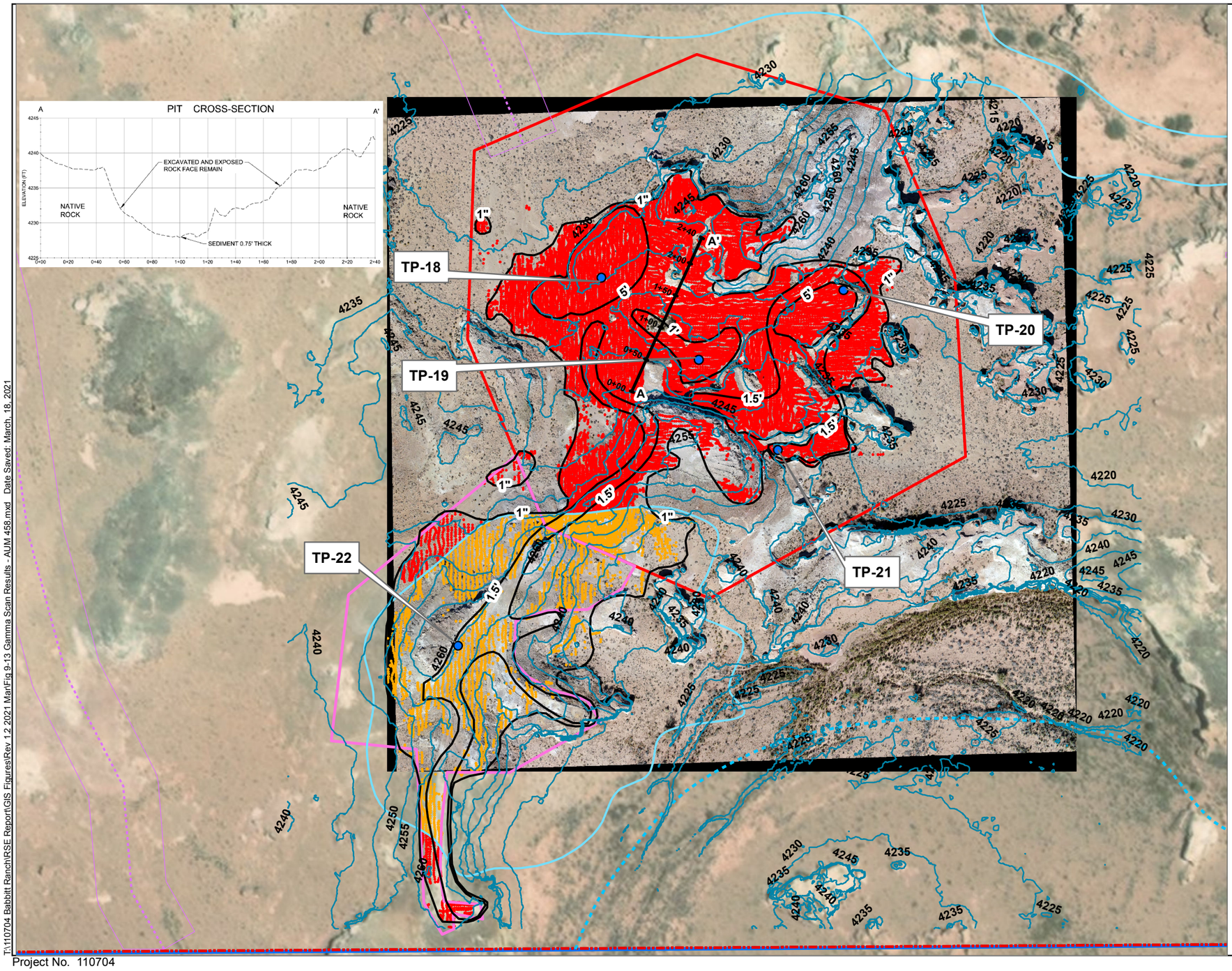
FIGURE 9-12
RESULTS OF MOBILE GAMMA SCAN SURVEY ABOVE IL WITH TEST PIT LOCATIONS
SW QUADRANT
BABBITT RANCHES



LEGEND

- Phase III Test Pits
- Alluvial TENORM Gamma Result above IL
- Drainage TENORM Gamma Result above IL
- Existing Contours (Maser, 2016)
- Depth of TENORM above IL Contours
- Cross Section A-A'
- EPA AUM Boundary
- Area of Potential Effect
- Section Lines
- Other Mine Related Disturbance (1)
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline

NOTES:
1) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).
2) The IL Application Areas are shown on Figure 5-14.
3) IL Values are as follows:

TABLE A: HORIZONTAL CORRELATION

Pool	Background pCi/g	IL pCi/g	gamma - mean cpm
Drainage	1.71	2.95	48419
Alluvial	3.72	4.96	67169
LCR	1.26	2.5	44221

TABLE B: VERTICAL CORRELATION

Pool	Background pCi/g	IL pCi/g	NET gamma - mean cpm
Drainage	1.71	2.95	1828
Alluvial	3.72	4.96	2307
LCR	1.26	2.5	1721

4) Total volume of TENORM above IL in this Quadrant: 7818 Cu. Yd.
5) Not all 1" contours are shown.

0 75 150 300 Feet

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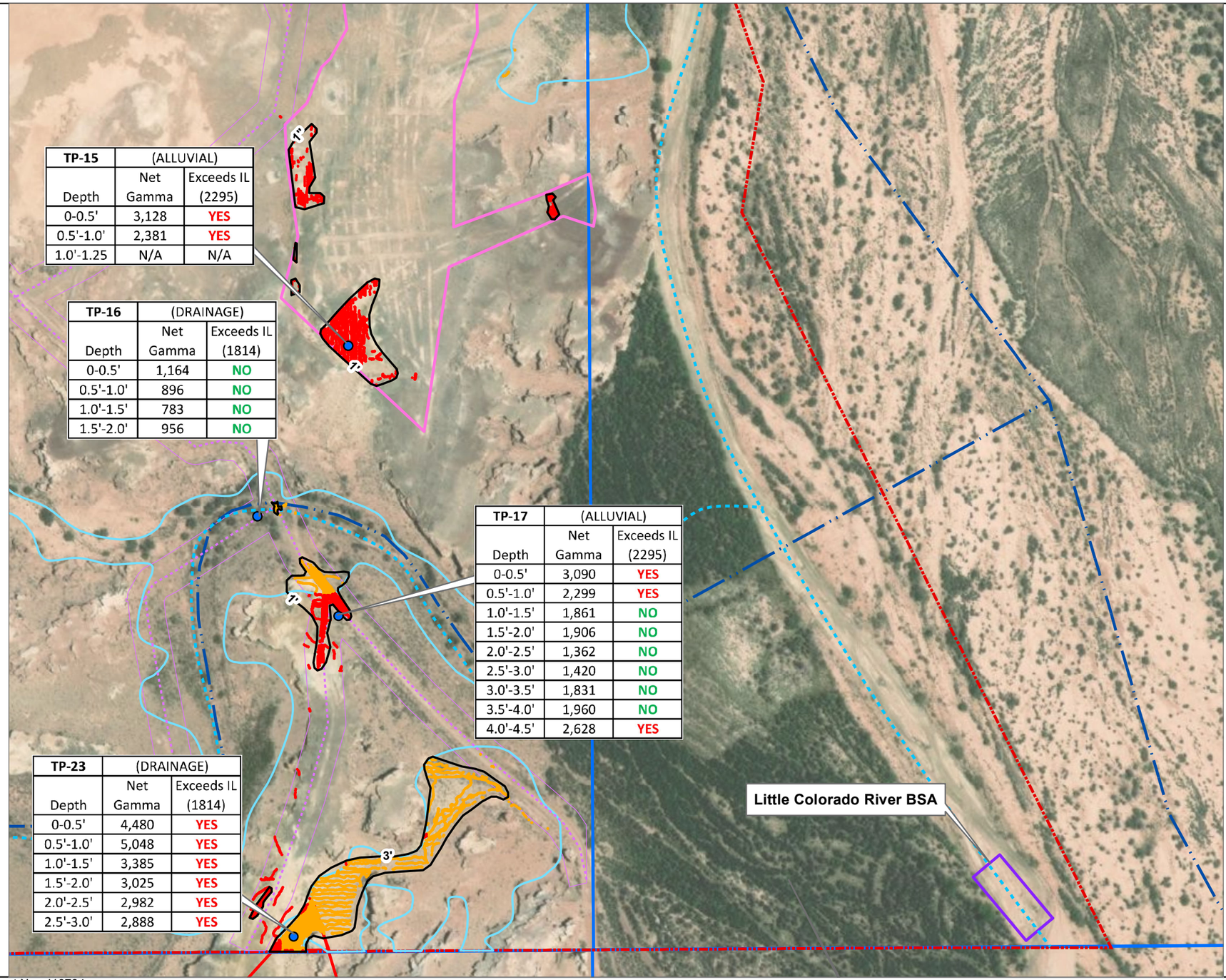
FIGURE 9-13
VOLUME ESTIMATE ABOVE IL AT AUM 458
BABBITT RANCHES



TP-15	(ALLUVIAL)	
Depth	Net Gamma	Exceeds IL (2295)
0-0.5'	3,128	YES
0.5'-1.0'	2,381	YES
1.0'-1.25	N/A	N/A

TP-16	(DRAINAGE)	
Depth	Net Gamma	Exceeds IL (1814)
0-0.5'	1,164	NO
0.5'-1.0'	896	NO
1.0'-1.5'	783	NO
1.5'-2.0'	956	NO

TP-17	(ALLUVIAL)	
Depth	Net Gamma	Exceeds IL (2295)
0-0.5'	3,090	YES
0.5'-1.0'	2,299	YES
1.0'-1.5'	1,861	NO
1.5'-2.0'	1,906	NO
2.0'-2.5'	1,362	NO
2.5'-3.0'	1,420	NO
3.0'-3.5'	1,831	NO
3.5'-4.0'	1,960	NO
4.0'-4.5'	2,628	YES

TP-23	(DRAINAGE)	
Depth	Net Gamma	Exceeds IL (1814)
0-0.5'	4,480	YES
0.5'-1.0'	5,048	YES
1.0'-1.5'	3,385	YES
1.5'-2.0'	3,025	YES
2.0'-2.5'	2,982	YES
2.5'-3.0'	2,888	YES

LEGEND

- Phase III Test Pits
- Depth of TENORM above IL Contours
- Alluvial TENORM Gamma Result above IL
- Drainage TENORM Gamma Result above IL
- EPA Identified Road Centerline
- EPA Identified Drainage Network
- 2019 Little Colorado River (NHD)
- EPA Identified Drainage Area Boundary
- EPA Identified Road Buffer (50-ft)
- Other Mine Related Disturbance (1)
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary

NOTES:
1) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).
2) The IL Application Areas are shown on Figure 5-14.
3) IL Values are as follows:

TABLE A: HORIZONTAL CORRELATION			
Pool	Background pCi/g	IL pCi/g	gamma - mean cpm
Drainage	1.71	2.95	48419
Alluvial	3.72	4.96	67169
LCR	1.26	2.5	44221

TABLE B: VERTICAL CORRELATION			
Pool	Background pCi/g	IL pCi/g	NET gamma - mean cpm
Drainage	1.71	2.95	1828
Alluvial	3.72	4.96	2307
LCR	1.26	2.5	1721

4) Total volume of TENORM above IL in this Quadrant: 9436 Cu. Yd.
5) Not all 1" contours are shown.

N

0 150 300 600
Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 9-14 Gamma Scan Results - SE w TP.mxd Date Saved: March. 18, 2021

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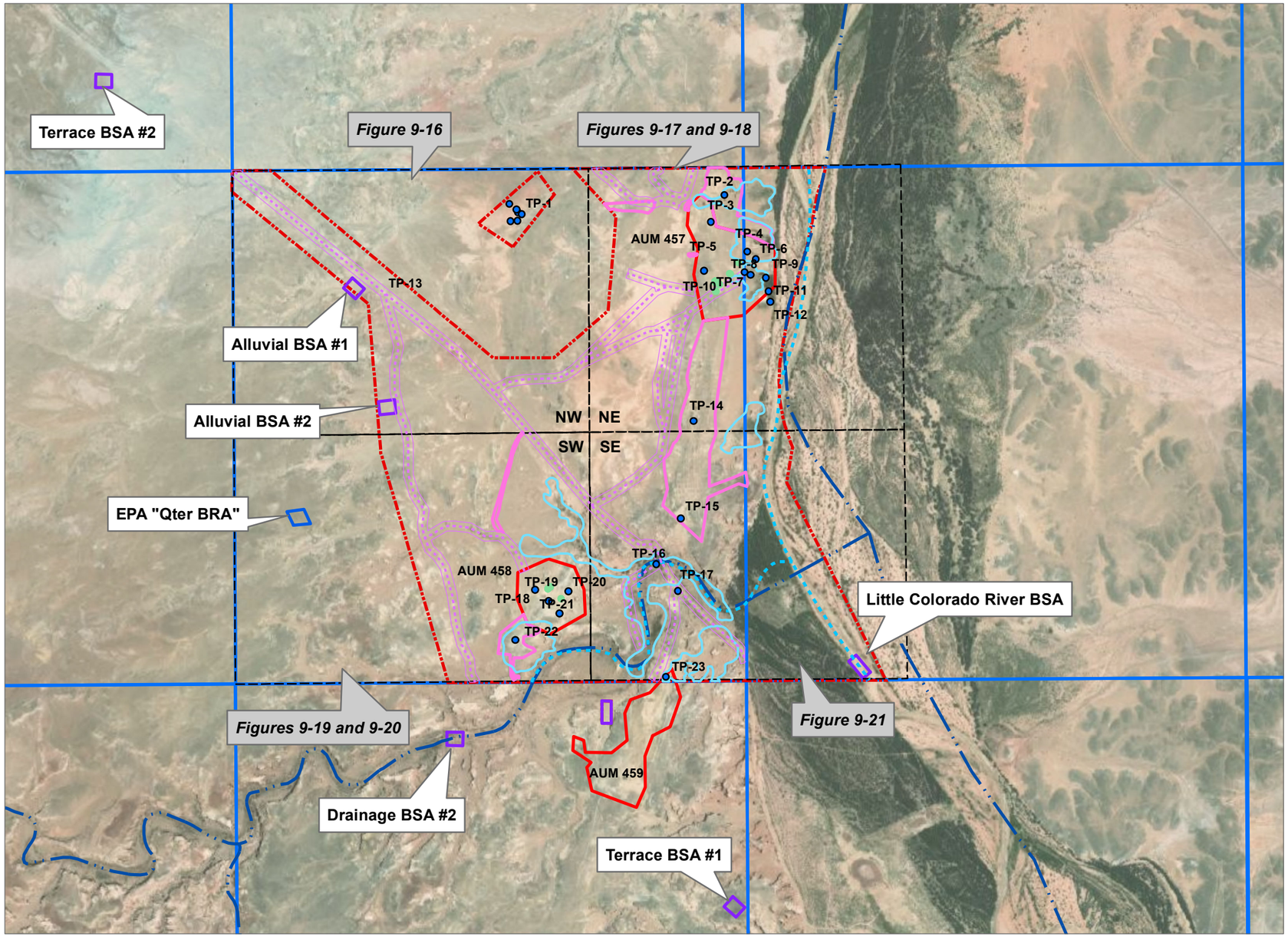
FIGURE 9-14
RESULTS OF MOBILE GAMMA SCAN SURVEY ABOVE IL WITH TEST PIT LOCATIONS
SE QUADRANT
BABBITT RANCHES



LEGEND

- Tenorm Results Above 160 pCi/g
- Phase III Test Pits
- EPA Identified Road Centerline
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- 2019 Little Colorado River (NHD)
- EPA Identified Road Buffer (50-ft)
- Other Mine Related Disturbance (1)
- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary

NOTES:
1) Other Mine Related Disturbance as Defined in the Phase II Work Plan (approved September 6, 2017).
2) Total Removal Volume for 160 pCi/g in the 4 quadrants is estimated to be 942 cubic yards.

N

0 625 1,250 2,500
Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mxd\Fig 9-15 Gamma Scan Results w TP - Risk Based.mxd Date Saved: March, 18, 2021

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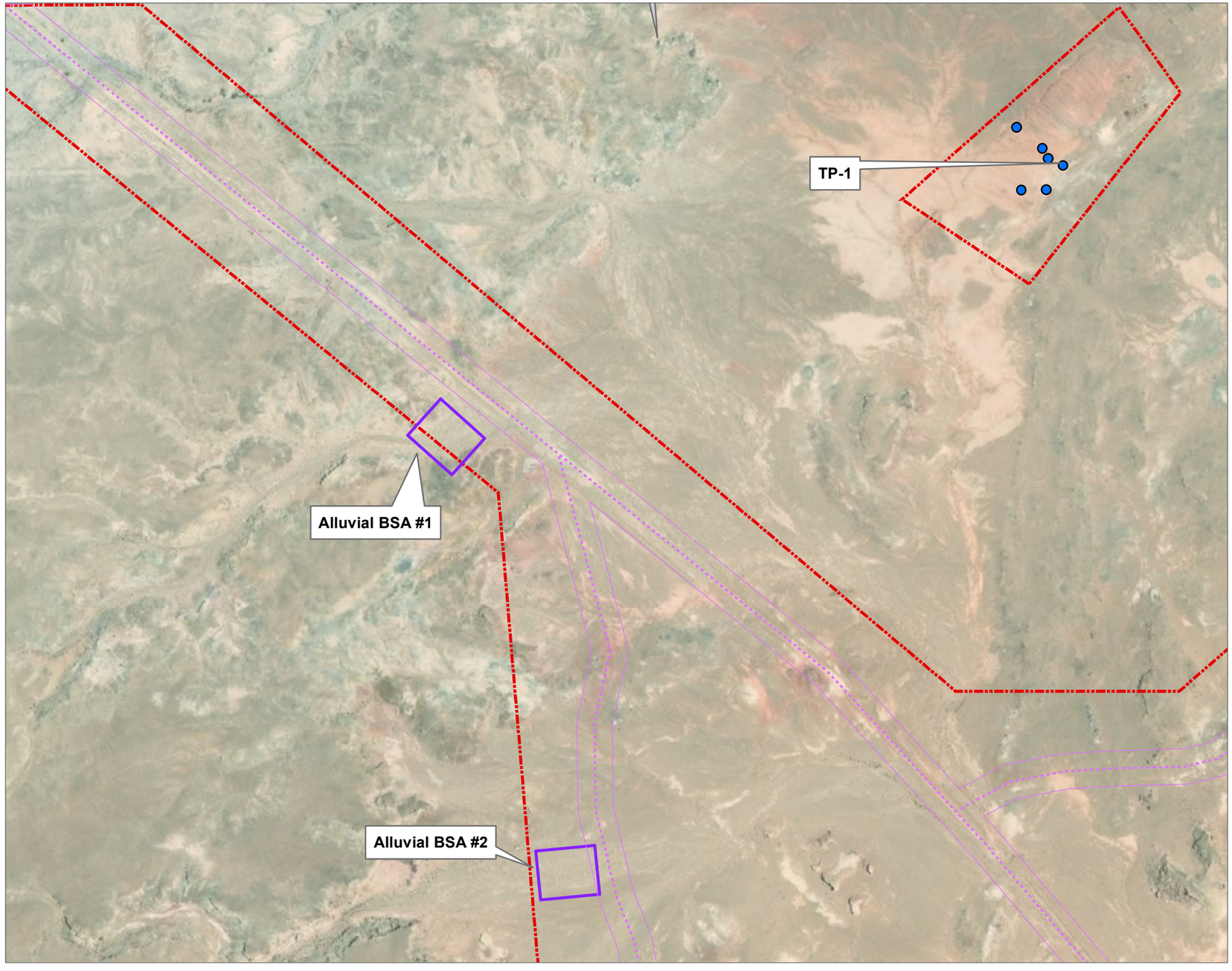
FIGURE 9-15
RISK BASED RESULTS OF MOBILE GAMMA SCAN SURVEY ABOVE 160 pCi/g AND TEST PIT LOCATIONS
BABBITT RANCHES



LEGEND

- TENORM Results Above 160 pCi/g
- Phase III Test Pits
- Babbitt BSA Locations
- Area of Potential Effect
- EPA Identified Drainage Area Boundary
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline

Notes:
1) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).
2) No risk based removal volume in this quadrant.

N

0 125 250 500
Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mxd\Fig 9-16 Gamma Scan Results 160 - NW - Risk Based.mxd Date Saved: March, 18, 2021

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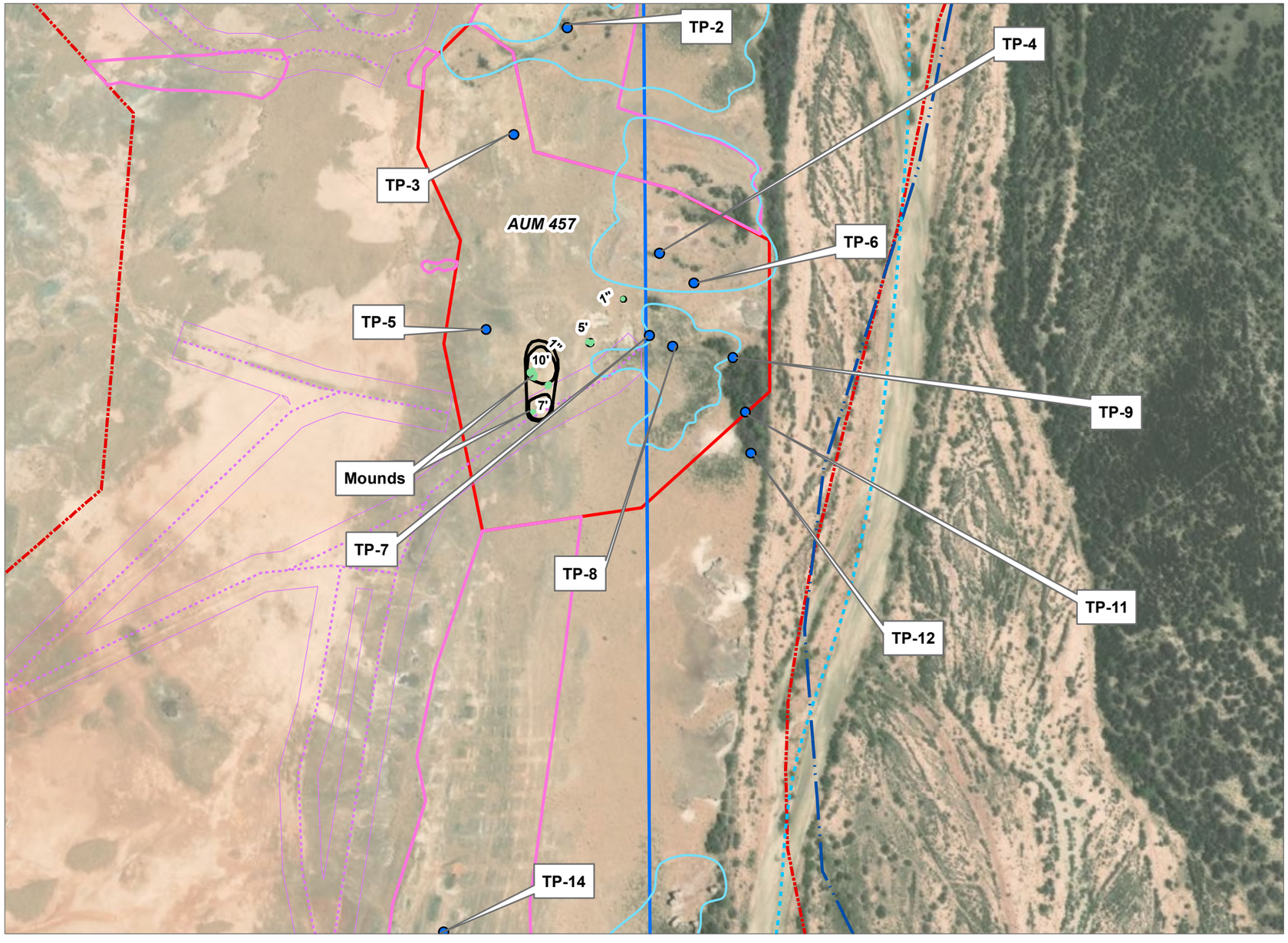
FIGURE 9-16
RISK BASED RESULTS OF MOBILE GAMMA SCAN SURVEY ABOVE 160 pCi/g
NW QUADRANT
BABBITT RANCHES



LEGEND

- TENORM Results Above 160 pCi/g
- Phase III Test Pits
- Risk Based Action Level Contours
- EPA Identified Road Centerline
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- 2019 Little Colorado River (NHD)
- EPA Identified Road Buffer (50-ft)
- Other Mine Related Disturbance (1)
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary

Notes:
1) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).
2) Total Removal Volume for this quadrant is shown on Figure 9-18.
3) Some 1" contours may not be shown.

N

0 125 250 500
Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mxd\Fig 9-17 Gamma Scan Results 160 - NE - Risk Based.mxd Date Saved: March, 18, 2021

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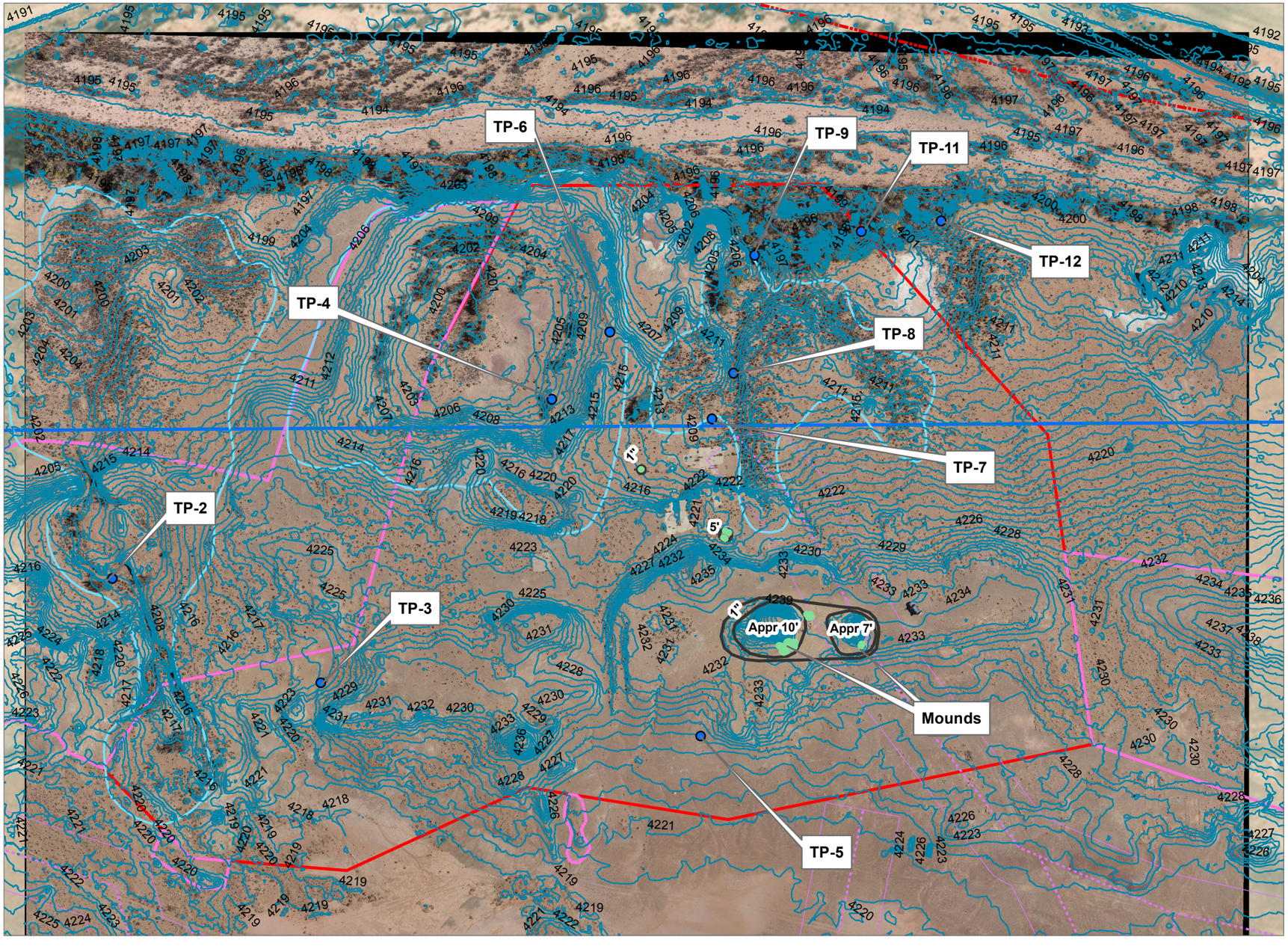
FIGURE 9-17
RISK BASED RESULTS OF MOBILE GAMMA SCAN SURVEY ABOVE 160 pCi/g
NE QUADRANT
BABBITT RANCHES



LEGEND

- TENORM Results Above 160 pCi/g
- Phase III Test Pits
- Risk Based Action Level Contours
- Existing Contours (Maser, 2016)
- EPA AUM Boundary
- Area of Potential Effect
- Section Lines
- Other Mine Related Disturbance (1)
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline

NOTES:
1) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).
2) Total Removal Volume of TENORM above 160 pCi/g in this Quadrant is estimated to be 940 Cu. Yd.
3) Some 1" contours may not be shown.

N

0 75 150 300
Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 9-18 Gamma Scan Results AUM 457 - Risk Based.mxd Date Saved: March 18, 2021

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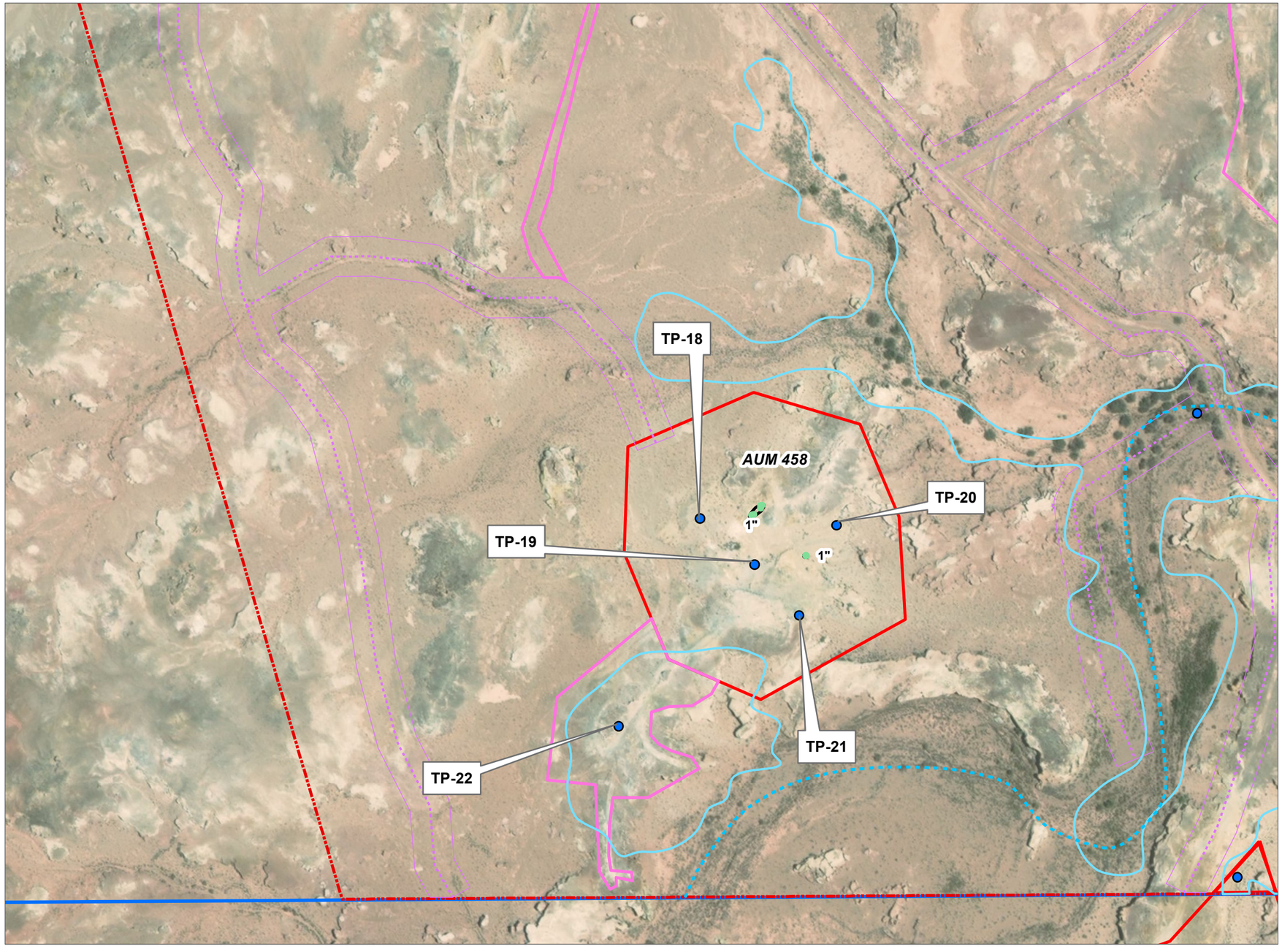
FIGURE 9-18
VOLUME ESTIMATE ABOVE 160 pCi/g AT AUM 457
BABBITT RANCHES



LEGEND

- TENORM Results Above 160 pCi/g
- Phase III Test Pits
- Risk Based Action Level Contours
- EPA AUM Boundary
- Area of Potential Effect
- Section Lines
- Other Mine Related Disturbance (1)
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline

NOTES:

1) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).
2) Total Removal Volume for this quadrant is shown on Figure 9-20.
3) Some 1" contours may not be shown.

N

0 125 250 500 Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 9-19 Gamma Scan Results 160 - SW - Risk Based.mxd Date Saved: March, 18, 2021

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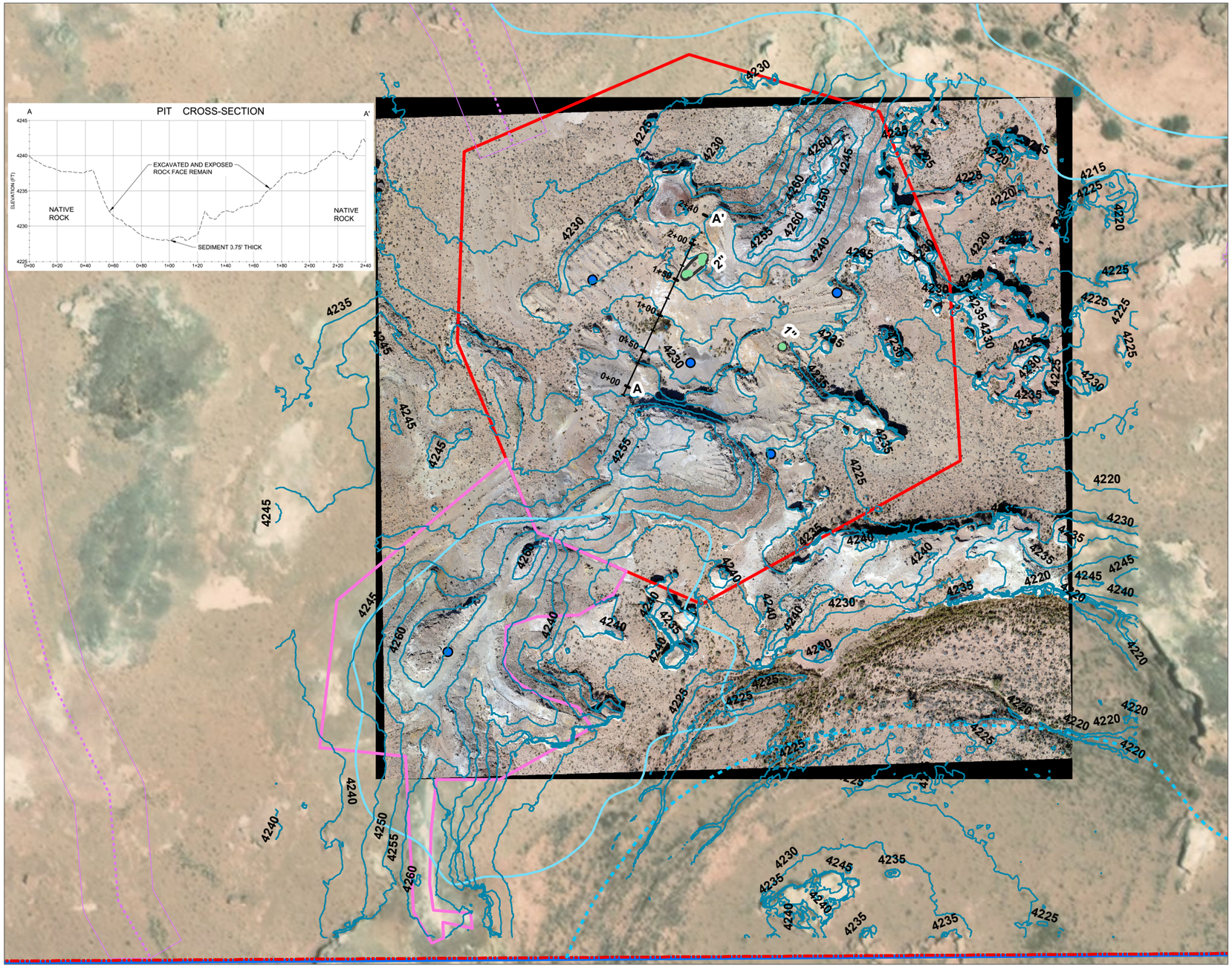
FIGURE 9-19
RISK BASED RESULTS OF MOBILE GAMMA SCAN SURVEY ABOVE 160 pCi/g
SW QUADRANT
BABBITT RANCHES



LEGEND

- TENORM Results Above 160 pCi/g
- Phase III Test Pits
- Risk Based Action Level Contours
- Existing Contours (Maser, 2016)
- Cross Section A-A'
- EPA AUM Boundary
- Area of Potential Effect
- Section Lines
- Other Mine Related Disturbance (1)
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- EPA Identified Road Buffer (50-ft)
- EPA Identified Road Centerline

NOTES:

1) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).
2) Total Removal Volume of TENORM above 160 pCi/g in this Quadrant is estimated to be 2 Cu. Yd.
3) Some 1" contours may not be shown.

N

0 75 150 300
Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 9-20 Gamma Scan Results AUM 458 - Risk Based.mxd Date Saved: March 18, 2021

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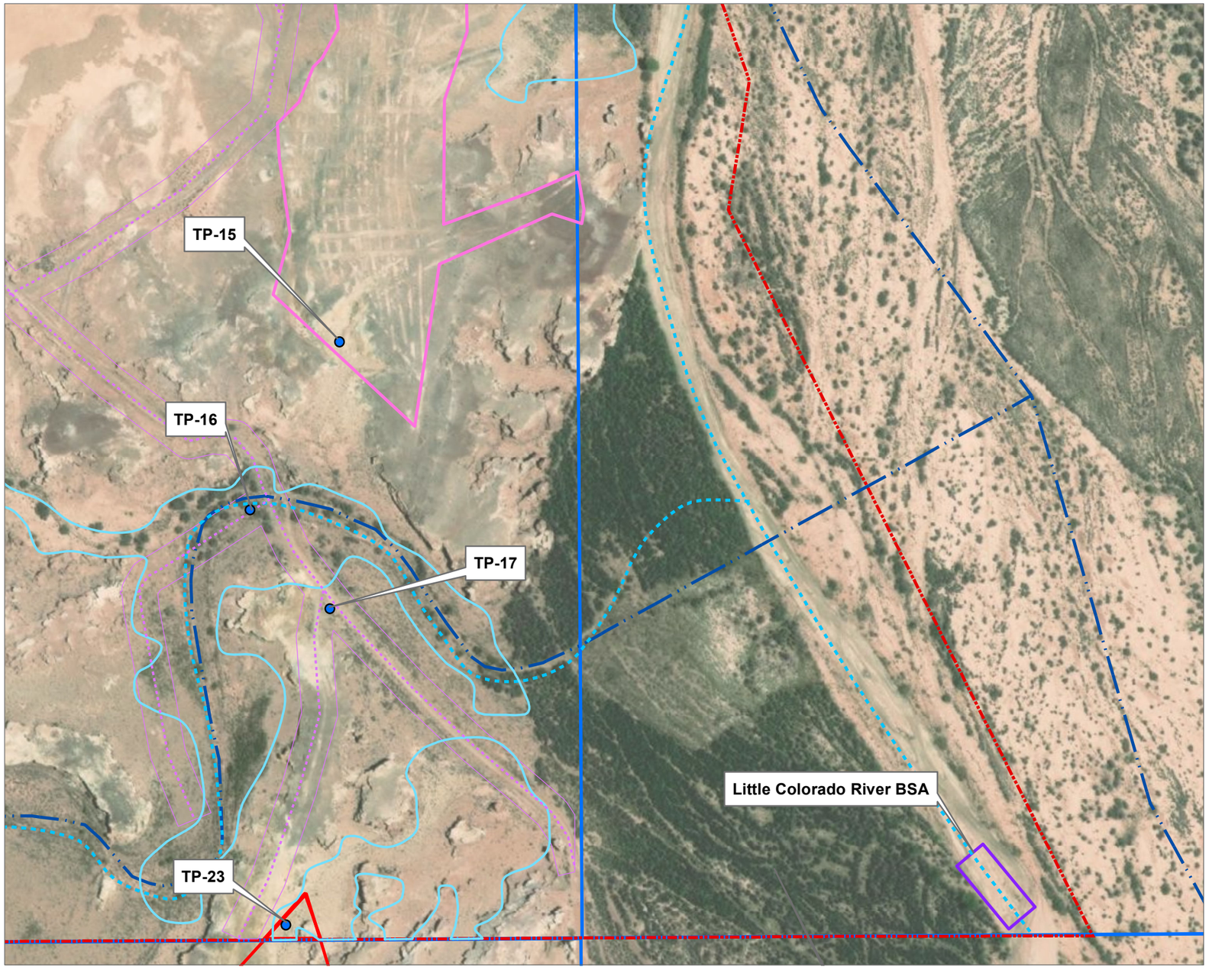
FIGURE 9-20
VOLUME ESTIMATE ABOVE 160 pCi/g AT AUM 458
BABBITT RANCHES



LEGEND

- TENORM Results Above 160 pCi/g
- Phase III Test Pits
- Risk Based Level Contours
- EPA Identified Road Centerline
- EPA Identified Drainage Area Boundary
- EPA Identified Drainage Network
- 2019 Little Colorado River (NHD)
- EPA Identified Road Buffer (50-ft)
- Other Mine Related Disturbance 1)
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary

NOTES:
1) Other Mine Related Disturbance as Defined in the Phase II Work Plan appeared (September 6, 2017)
2) No risk based removal volume in this quadrant.

N

0 125 250 500
Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 9-21 Gamma Scan Results 160 - SE - Risk Based.mxd Date Saved: March, 18, 2021

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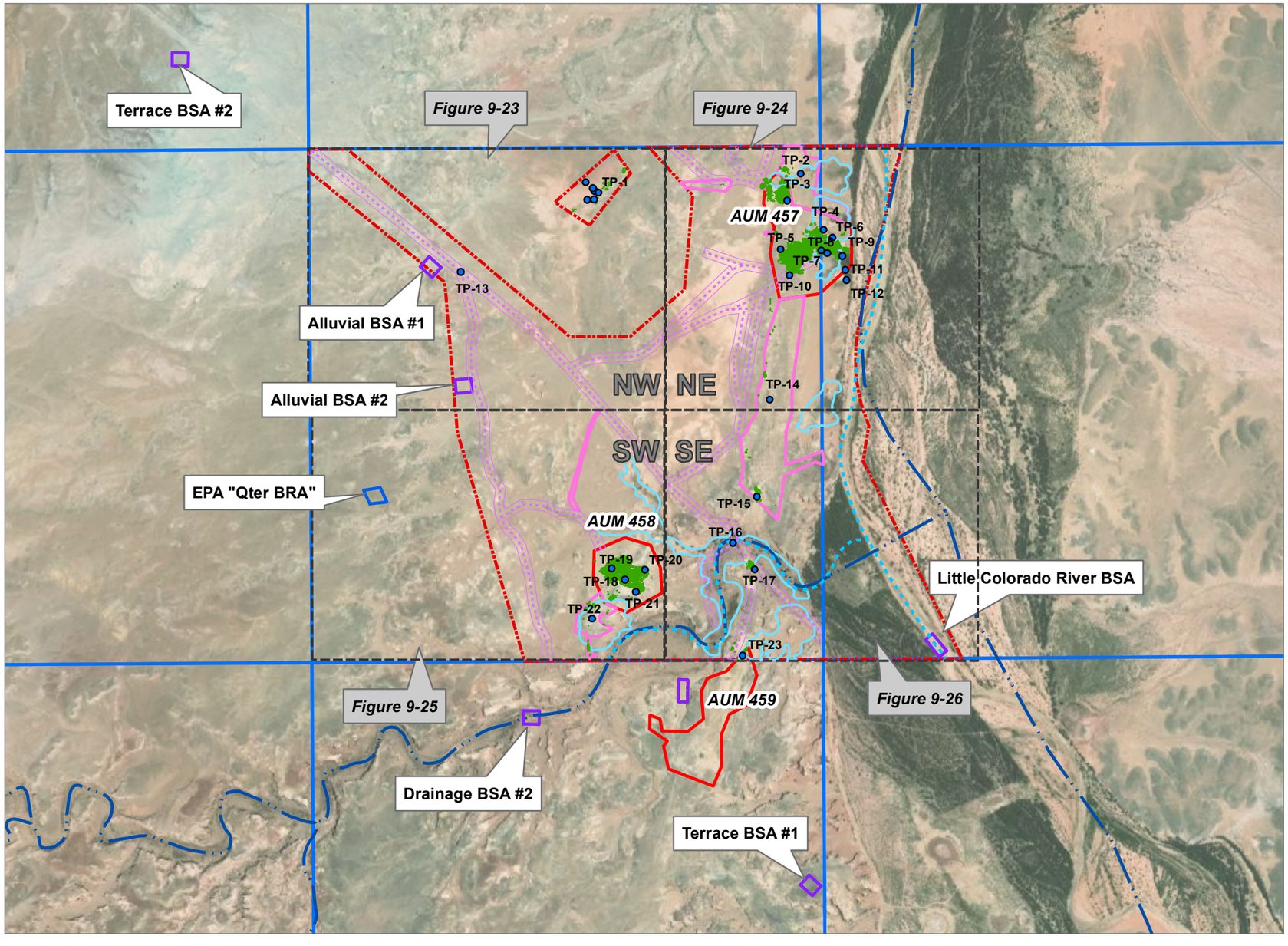
FIGURE 9-21
RISK BASED RESULTS OF MOBILE GAMMA SCAN SURVEY ABOVE 160 pCi/g
SE QUADRANT
BABBITT RANCHES



LEGEND

- Phase III Test Pits
- TENORM Results above 12 pCi/g
- EPA Identified Road Centerline
- EPA Identified Drainage Network
- 2019 Little Colorado River (NHD)
- EPA Identified Drainage Area Boundary
- EPA Identified Road Buffer (50-ft)
- Other Mine Related Disturbance (1)
- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary

NOTES:
1) Other Mine Related Disturbance as Defined in the Phase II Work Plan (approved September 6, 2017).
2) Total Volume removal estimate per area is on figures 9-23 through 9-26.
3) Total Removal Volume for 12 pCi/g in the 4 quadrants is estimated to be 10,036 cubic yards.

0 625 1,250 2,500 Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 9-22 Gamma Scan Results 12 w TP - Risk Based.mxd Date Saved: March, 18, 2021

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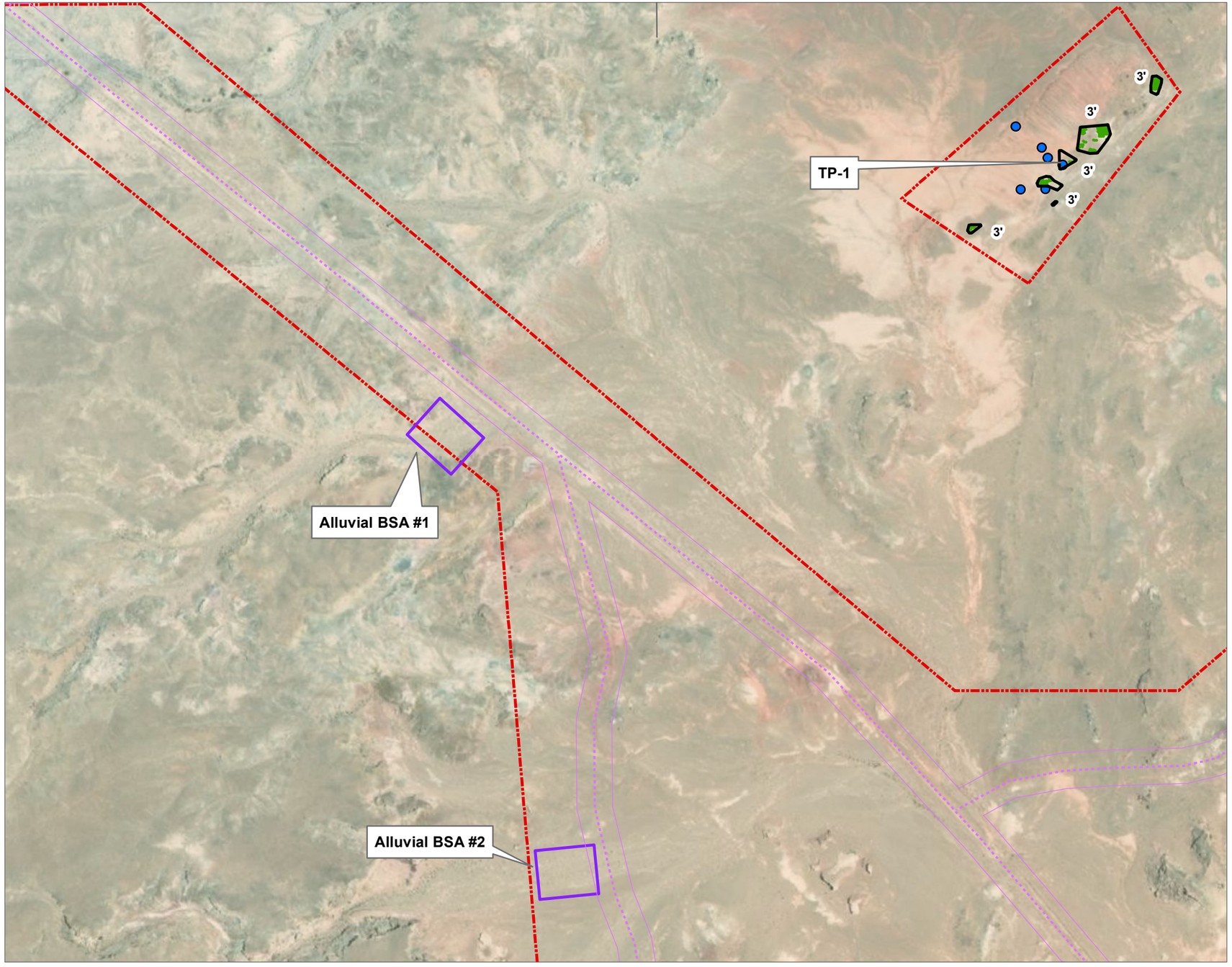
FIGURE 9-22
RISK BASED RESULTS OF MOBILE GAMMA SCAN SURVEY AND VOLUME ESTIMATE ABOVE 12 pCi/g AND TEST PIT LOCATIONS
BABBITT RANCHES



LEGEND

- TENORM Results Above 12 pCi/g
- Phase III Test Pits
- Risk Based Action Level Contours 12 pCi/g
- EPA Identified Road Centerline
- EPA Identified Drainage Area Boundary
- EPA Identified Road Buffer (50-ft)
- Babbitt BSA Locations
- Area of Potential Effect

Notes:

1) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).
2) Total Removal Volume in this quadrant is estimated to be 1,166 cubic yards.
3) All removal contours in this quadrant are 3 feet deep.

N

0 125 250 500
Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 9-23 Gamma Scan Results 12 - NW - Risk Based.mxd Date Saved: March, 18, 2021

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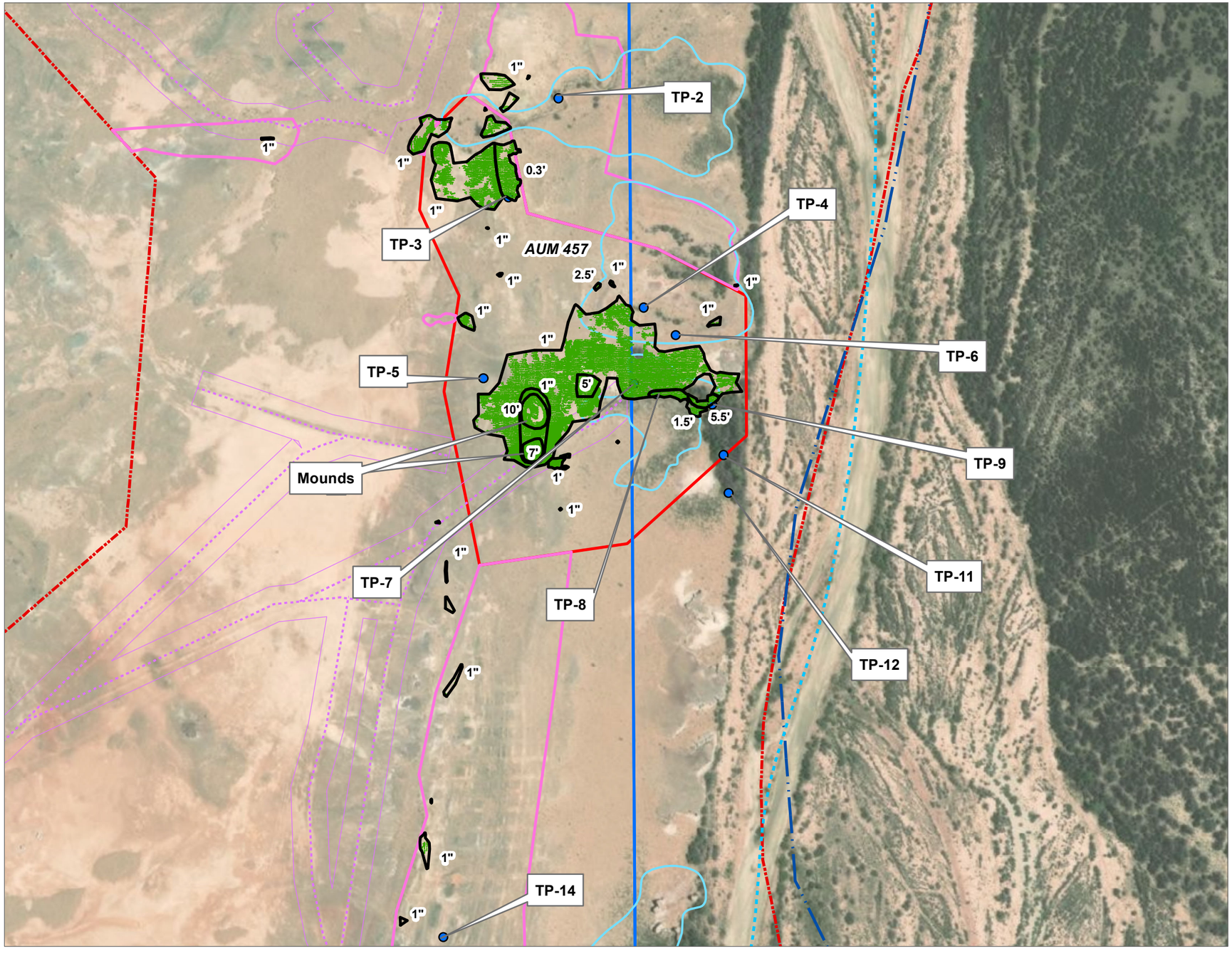
FIGURE 9-23
RISK BASED RESULTS OF MOBILE GAMMA SCAN SURVEY AND VOLUME ESTIMATE ABOVE 12 pCi/g
NW QUADRANT
BABBITT RANCHES



LEGEND

- Risk Based Action Level Contour 12 pCi/g
- Phase III Test Pits
- TENORM Results Above 12 pCi/g
- EPA Identified Road Centerline
- EPA Identified Drainage Network
- 2019 Little Colorado River (NHD)
- EPA Identified Drainage Area Boundary
- EPA Identified Road Buffer (50-ft)
- Other Mine Related Disturbance (1)
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary

Notes:

1) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).
2) Total Removal Volume for this quadrant is estimated to be 2,688 cubic yards.
3) Some 1" contours may not be shown.

N

0 125 250 500 Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 9-24 Gamma Scan Results 12 - NE - Risk Based.mxd Date Saved: March, 18, 2021

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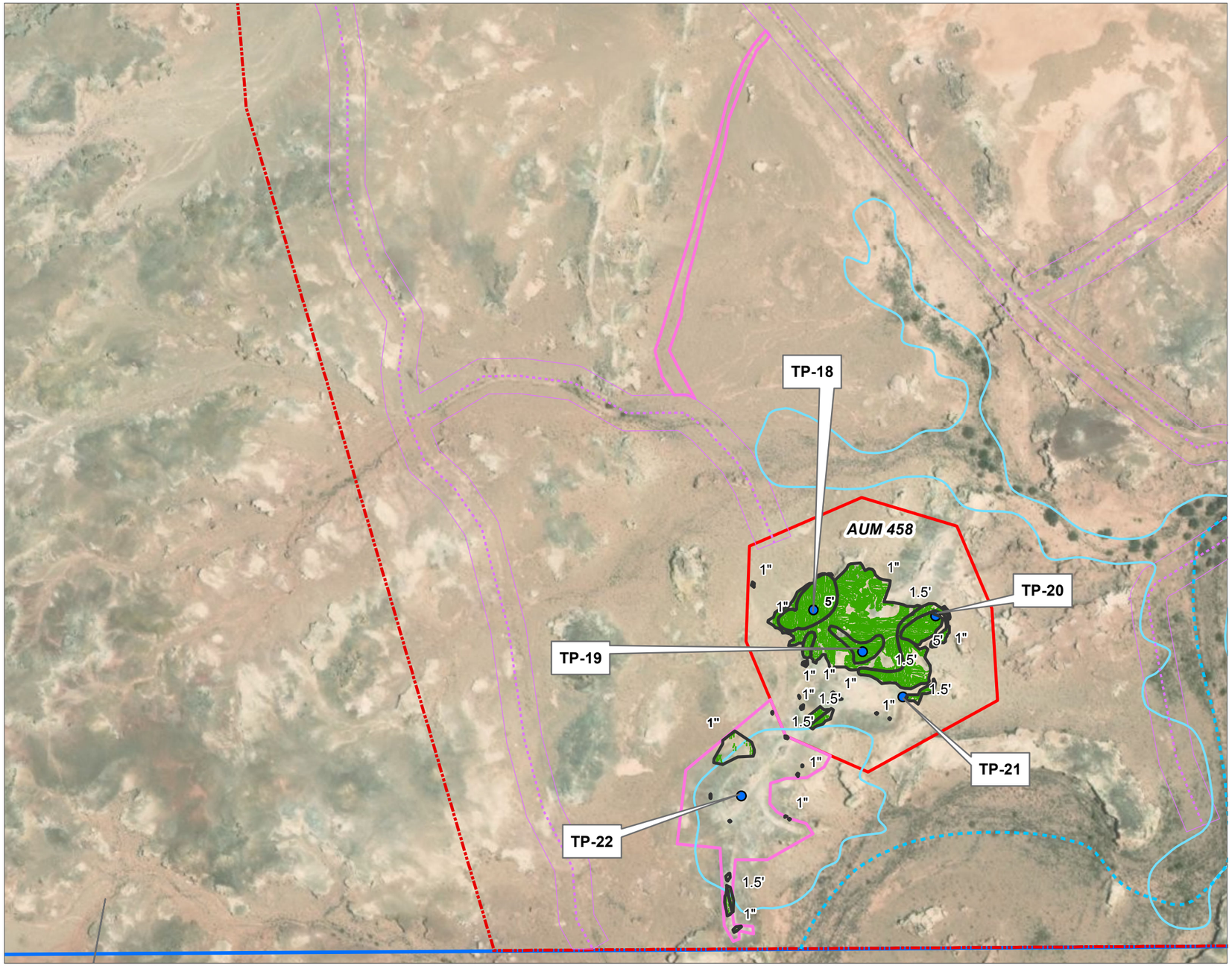
FIGURE 9-24
RISK BASED RESULTS OF MOBILE GAMMA SCAN SURVEY AND VOLUME ESTIMATE ABOVE 12 pCi/g
NE QUADRANT
BABBITT RANCHES



LEGEND

- TENORM Results Above 12 pCi/g
- Phase III Test Pits
- Risk Based Action Level Contours 12 pCi/g
- EPA Identified Drainage Network
- EPA Identified Road Centerline
- EPA Identified Drainage Area Boundary
- EPA Identified Road Buffer (50-ft)
- Other Mine Related Disturbance (1)
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary

NOTES:
1) Other Mine Related Disturbance as defined in the Phase II Work Plan (approved September 6, 2017).
2) Total Removal Volume for this quadrant is estimated to be 5,535 cubic yards.
3) Some 1" contours may not be shown.

N

0 125 250 500
Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 9-25 Gamma Scan Results 12- SW - Risk Based.mxd Date Saved: March, 18, 2021

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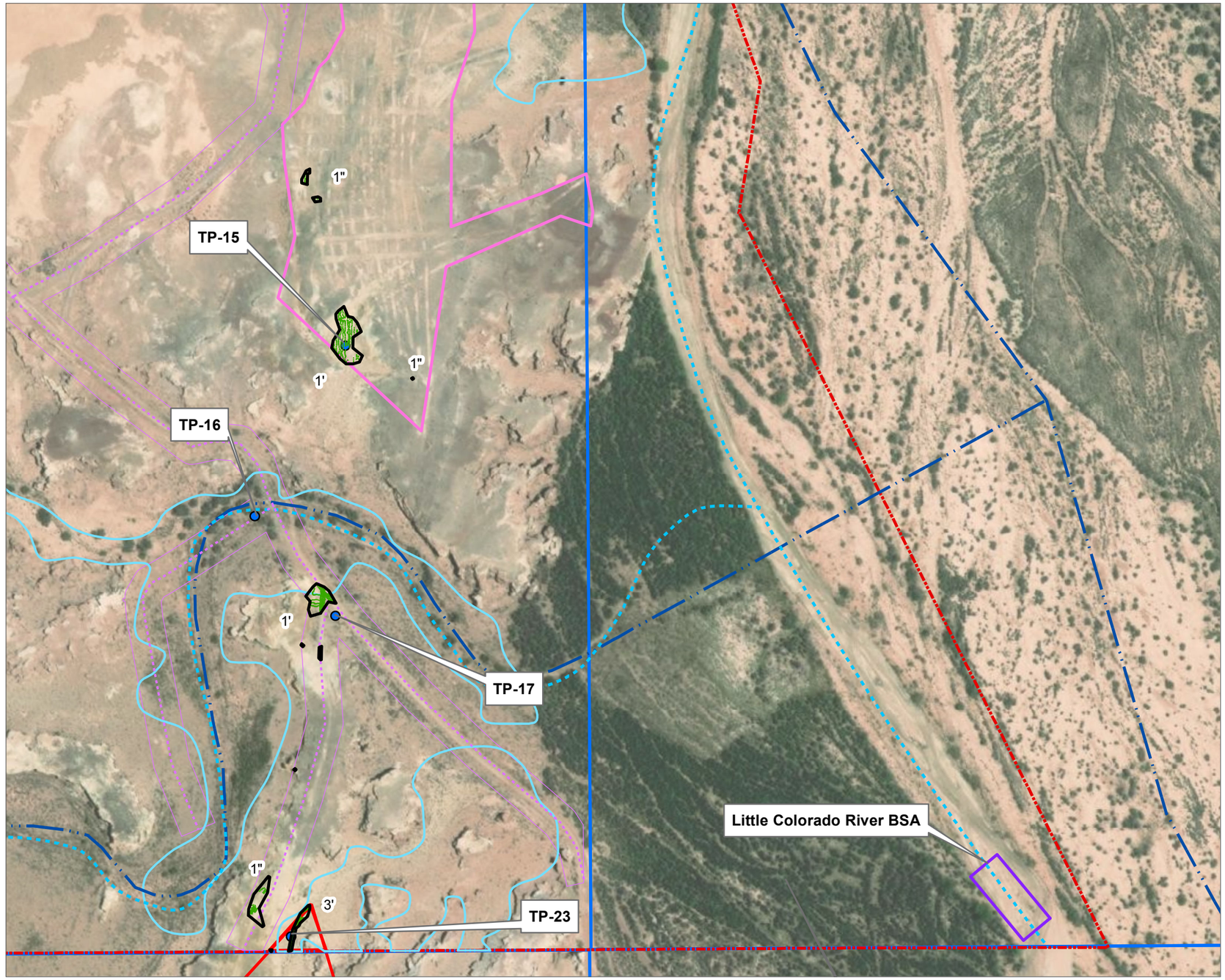
FIGURE 9-25
RISK BASED RESULTS OF MOBILE GAMMA SCAN SURVEY AND VOLUME ESTIMATE ABOVE 12 pCi/g
SW QUADRANT
BABBITT RANCHES



LEGEND

- Risk Based Level Countours 12 pCi/g
- TENORM Results Above 12 pCi/g
- Phase III Test Pits
- EPA Identified Road Centerline
- EPA Identified Drainage Network
- 2019 Little Colorado River (NHD)
- EPA Identified Drainage Area Boundary
- EPA Identified Road Buffer (50-ft)
- Other Mine Related Disturbance 1)
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary

NOTES:
1) Other Mine Related Disturbance as Defined in the Phase II Work Plan appeared (September 6, 2017)
2) Total Removal Volume for this quadrant is estimated to be 647 cubic yards.

N

0 125 250 500
Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 9-26 Gamma Scan Results 12 - SE - Risk Based.mxd Date Saved: March, 18, 2021

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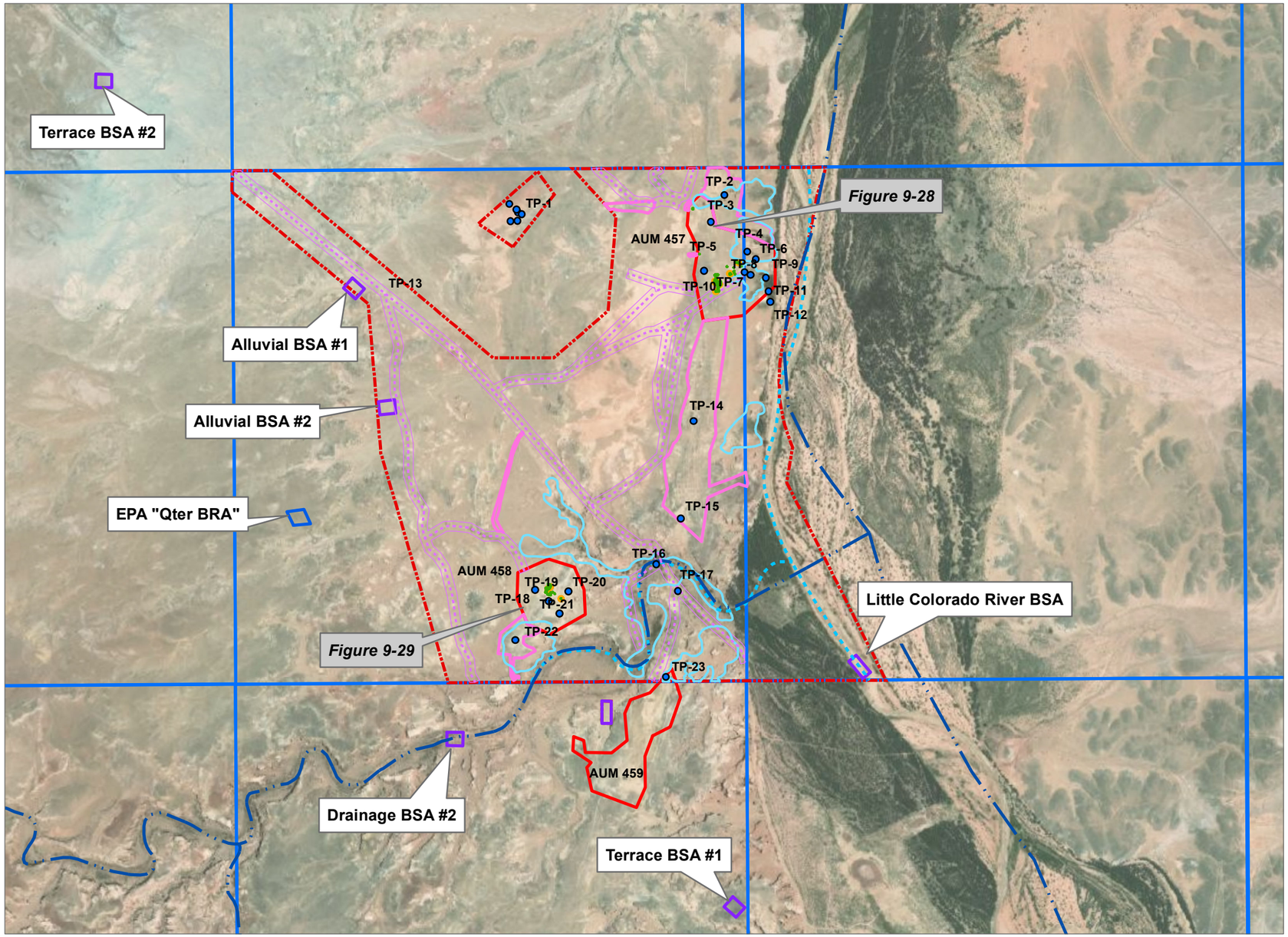
FIGURE 9-26
RISK BASED RESULTS OF MOBILE GAMMA SCAN SURVEY AND VOLUME ESTIMATE ABOVE 12 pCi/g
SE QUADRANT
BABBITT RANCHES



LEGEND

- TENORM Results above 12 pCi/g
- Tenorm Results Above 160 pCi/g
- Phase III Test Pits
- EPA Identified Road Centerline
- 2019 Little Colorado River (NHD)
- EPA Identified Drainage Network
- EPA Identified Drainage Area Boundary
- EPA Identified Road Buffer (50-ft)
- Other Mine Related Disturbance (1)
- EPA BRA Location
- Babbitt BSA Locations
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary

NOTES:
1) Other Mine Related Disturbance as Defined in the Phase II Work Plan (approved September 6, 2017).
2) Total Removal Volumes are shown in the table below.

AUM	Removal Volume		Difference
	>12 pCi/g	>160 pCi/g	
NE	2,688	940	1,748
SE	647	0	647
SW	5,535	2	5,533
NW	1,166	0	1,166
Total	10,036	942	9,094

N

0 625 1,250 2,500
Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Mar\Fig 9-27 Gamma Scan Results 12 & 160.mxd Date Saved: March, 18, 2021

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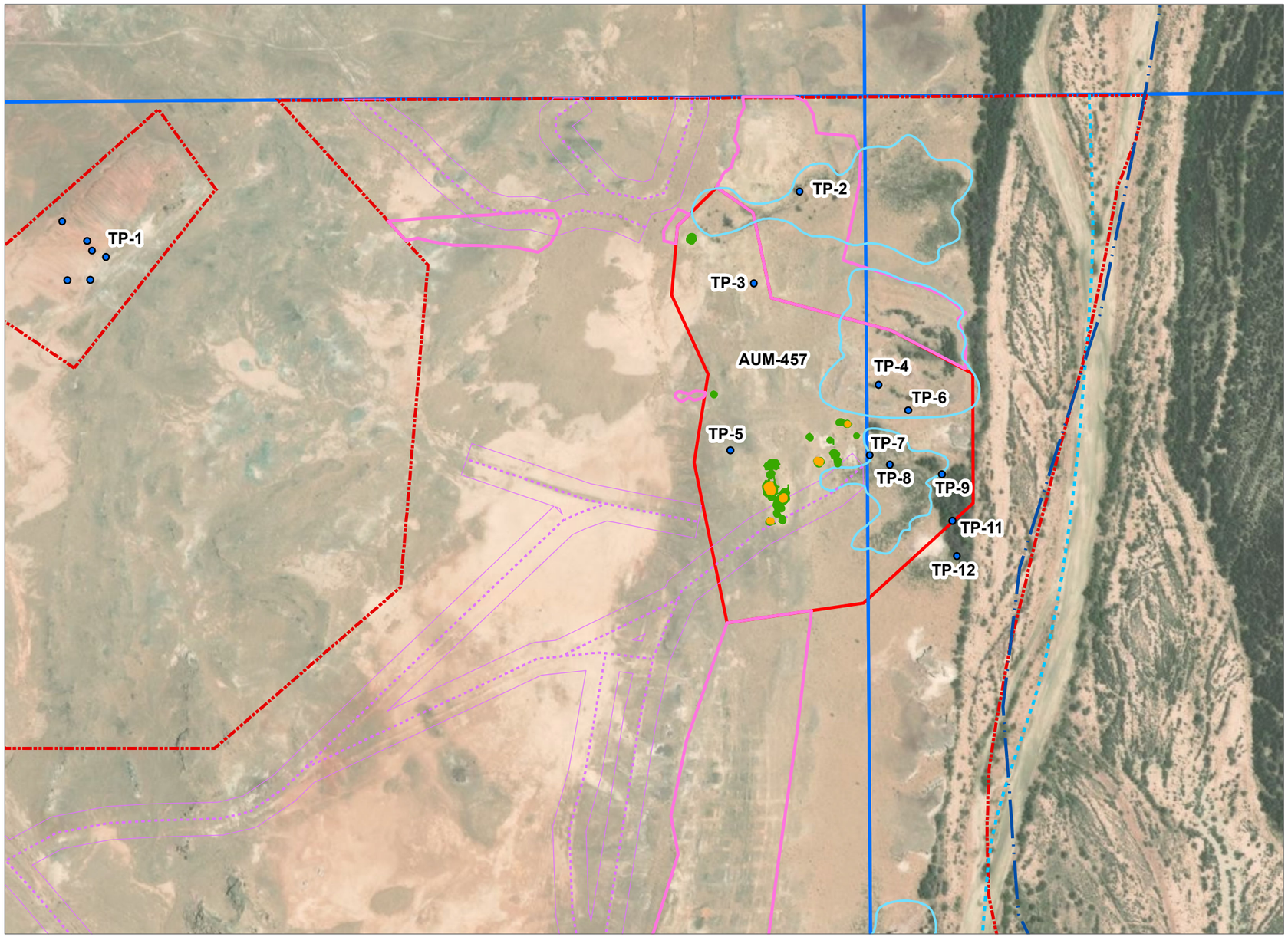
FIGURE 9-27
RISK BASED RESULTS OF MOBILE GAMMA SCAN SURVEYS COMPARING ABOVE 12 pCi/g AND ABOVE 160 pCi/g AND TEST PIT LOCATIONS
BABBITT RANCHES



LEGEND

- Tenorm Results Above 160 pCi/g
- TENORM Results Above 12 pCi/g
- Phase III Test Pits
- EPA Identified Road Centerline
- 2019 Little Colorado River (NHD)
- EPA Identified Drainage Network
- EPA Identified Drainage Area Boundary
- EPA Identified Road Buffer (50-ft)
- Other Mine Related Disturbance (1)
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary

NOTES:
1) Other Mine Related Disturbance as Defined in the Phase II Work Plan (approved September 6, 2017).
2) Total Removal Volumes are shown in the table on Figure 9-27.

N

0 175 350 700
Feet

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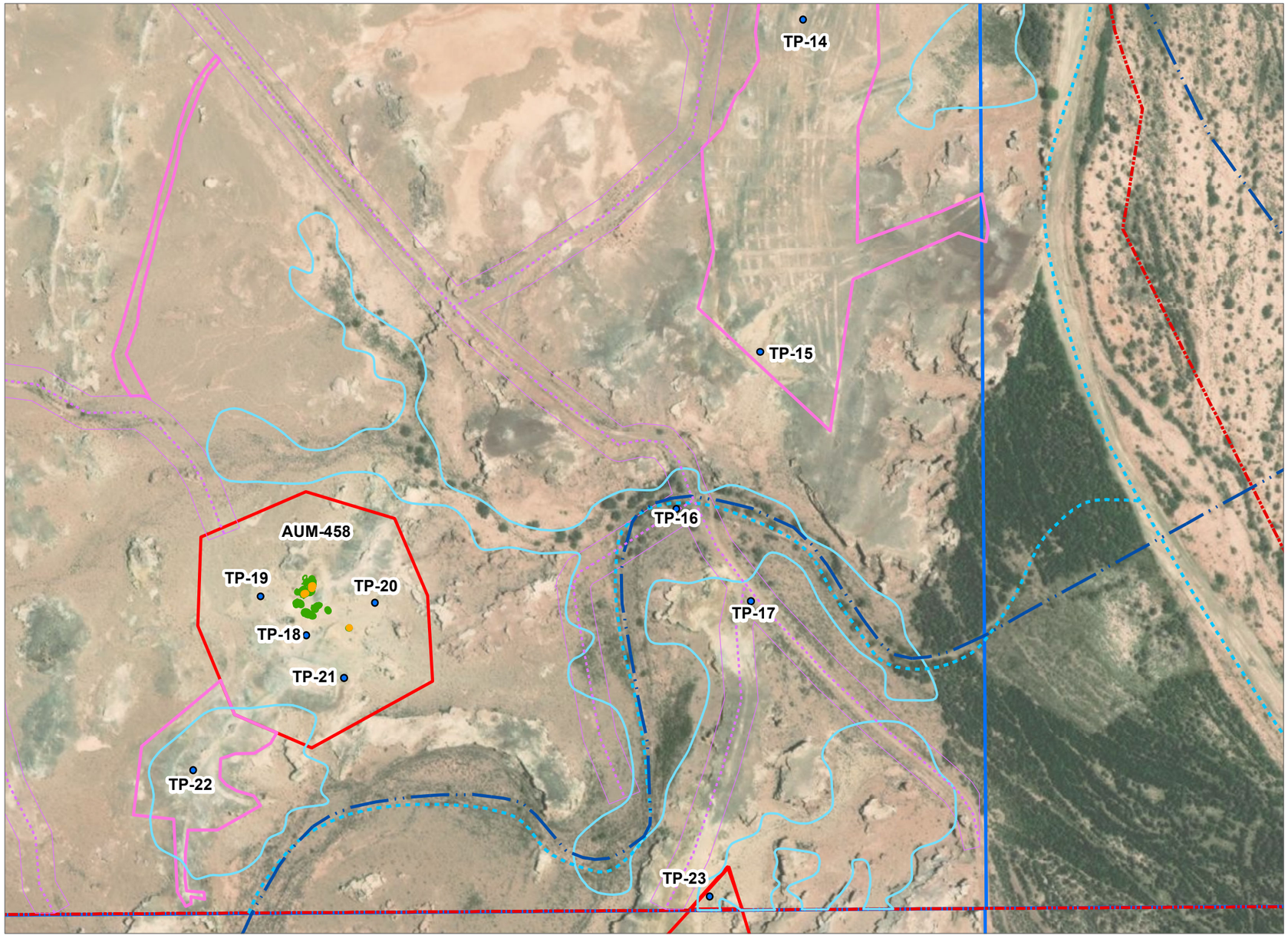
FIGURE 9-28
RISK BASED RESULTS OF MOBILE GAMMA SCAN SURVEYS COMPARING ABOVE 12 pCi/g AND ABOVE 160 pCi/g AND TEST PIT LOCATIONS
NE QUADRANT
BABBITT RANCHES



LEGEND

- Tenorm Results Above 160 pCi/g
- TENORM Results Above 12 pCi/g
- Phase III Test Pits
- EPA Identified Road Centerline
- 2019 Little Colorado River (NHD)
- EPA Identified Drainage Network
- EPA Identified Drainage Area Boundary
- EPA Identified Road Buffer (50-ft)
- Other Mine Related Disturbance (1)
- Area of Potential Effect
- Section Lines
- EPA AUM Boundary

NOTES:
1) Other Mine Related Disturbance as Defined in the Phase II Work Plan (approved September 6, 2017).
2) Total Removal Volumes are shown in the table on Figure 9-27.

N

0 175 350 700
Feet

T:\110704 Babbitt Ranch\RSE Report\GIS Figures\Rev 1.2 2021 Man\Fig 9-29 Gamma Scan Results 12 & 160 AUM-458.mxd Date Saved: March, 18, 2021

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FIGURE 9-29
RISK BASED RESULTS OF MOBILE GAMMA SCAN SURVEYS COMPARING ABOVE 12 pCi/g AND ABOVE 160 pCi/g AND TEST PIT LOCATIONS
SE QUADRANT
BABBITT RANCHES